THE CLASSIFICATION AND TREATMENT OF INJURIES TO THE TEETH OF CHILDREN

THIS VOLUME IS DEDICATED TO
THOSE UNFORTUNATE BOYS AND GIRLS FOR WHOM
THIS PROBLEM BECOMES A PERSONAL ONE.
THEIR HOPE IS THAT ALL DENTISTS EVERYWHERE
WILL MEET THE CHALLENGE THEY ISSUE AND
HELP THEM IN THEIR HOUR OF NEED.

The CLASSIFICATION and TREATMENT of INJURIES to the TEETH of CHILDREN • A REFERENCE MANUAL FOR THE DENTAL STUDENT AND THE GENERAL PRACTITIONER

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Preface to Fourth Edition

WHILE the main theme in this manual is classification and treatment of injuries, nevertheless, increasing emphasis must be placed on the *prevention* of injuries to the teeth of children. Positive preventive procedures are available in the form of mouth protectors. Their use is increasing in sports, but concerted educational measures are required to assure maximum protection to all children and young adults engaged in vigorous games.

It is the hope of the author that we will witness in the next decade or two general acceptance of means of preventing injuries to teeth and thereby a reduction in the need for providing treatment services. This happy state of affairs will come about only if we, as members of the profession, preach prevention at every opportunity.

The author is indebted to Dr. Marjorie Jackson, Associate Professor of Pedodontics at the University of Toronto, for assistance in revising some sections of this volume.

—R. G. E.

Preface to First Edition

ONE OF THE most tragic conditions which the student of dentistry or even the general practitioner has to face during the day's work is the fractured or traumatized anterior tooth in the young patient. An apparent increase in the incidence of accidents responsible for this distress is variously attributed to many factors, ranging from an increasing complexity of modern life to an increase in the prominence of the anterior teeth. Whatever the true nature of the cause, the restoration of these teeth is an extremely difficult and perplexing problem.

If we were to project in pictorial form the dramatic scene in the office of a busy dentist when a child arrives with traumatized anterior teeth, three individuals would be portrayed. First, there is the child patient, the victim of circumstances, thoroughly disconcerted and apprehensive; second, the parent, anxious for the child's well-being, and, third, the dentist, embarrassed by the emergency of the situation and possibly perplexed as to the best procedure to follow.

In such circumstances the confidence of the dentist can do much to allay the fears and apprehension of the patient and the parent. Such confidence can be assured only if it is born out of the knowledge of how best to achieve the results desired, namely,

preservation of the parts involved and their restoration to normal anatomic form, biologic health and functional efficiency.

With this in mind, the author presents this manual in a brief practical form hoping to familiarize dental students and general practitioners who read these pages with a simple direct approach to the various problems that may confront them in this field. Where numerous methods exist for the treatment of specific problems, only one or two have been chosen, in an endeavor to simplify the discussion.

In Chapter 1, a classification of injuries to the anterior teeth of the young patient has been enunciated, on which is based the treatment for the various types of cases. Then, at the beginning of each chapter, a prescription for treatment for the class of case dealt with in the chapter is outlined. This prescription for treatment is to be used for quick reference. Following this brief outline of treatment, a detailed study is given of the class of case being considered. Where possible, illustrations have been used freely to illuminate certain portions of the text.

The author wishes to acknowledge his indebtedness to Dr. I. H. Ante and Dr. S. M. Richardson, both members of the staff of the Faculty of Dentistry of the University of Toronto, for their help in the preparation of the illustrations; to Dr. P. W. Arkle of the staff of the Faculty of Dentistry of the University of Toronto and Mr. Nelson Dancy of the Ontario College of Art for their assistance in the preparation of the line drawings which appear throughout the book;

to Dr. J. C. Livett for the figures obtained from a survey made in a number of schools; to Miss M. Jackson for faithful and untiring secretarial assistance rendered in the compilation of the material herein presented. He desires also to thank the publishers for their co-operation in the execution of his wishes concerning the publication of this work.

–R. G. E.

Foreword to Second Edition

DURING MANY years of practice I had been interested in dental service for children and had always been conscious of a need for a book on the classification and treatment of injuries to the teeth of children. I am, therefore, grateful to Dr. Ellis for the concise and lucid manner in which he has prepared this manual. Dr. Ellis has had extensive experience in treating patients in the Faculty Clinic of the University of Toronto.

The subject has been presented in a logical way, and almost all of the accidents which happen to children's teeth are covered. The method of classifying and in addition giving the history, diagnosis and treatment in each case will appeal alike to undergraduates and to the busy practitioner.

This is the type of manual which immediately goes to the heart of the subject and applies the fundamental principles to practice. The second edition should enjoy an even greater acceptance than the first.

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University of Toronto

May 10, 1946

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THE CLASSIFICATION AND TREATMENT OF INJURIES TO THE TEETH OF CHILDREN

CHAPTER 1

Introduction

THE ANTERIOR teeth of both dentitions are interesting. Comparatively early in life they take their places in an exposed position in the mouth and become not only essential units in the mechanism of mastication but also prerequisite to the normal esthetics of the individual.

Their role in esthetics is primarily one of physical beauty, but indirectly their esthetic value becomes a primary factor in the *psychologic well-being* of the individual. Reference is made by many authors to the disturbances caused by disfiguring dental anomalies and their possible psychologic effects. Walker[1] contends that "All persons to a certain extent are sensitive; however when one has a deformity, this common trait may resolve into supersensitiveness. With certain children possessing disfiguring dental anomalies it is the same; their sensitiveness grows into supersensitiveness."

Brauer[2] refers to the possible effect a broken anterior tooth may have in these words: "An unsatisfactory restoration of a fractured tooth often leads to an inferiority complex, which may be a direct factor in the failure of that child in the future."

When the result of our effort becomes associated with and influences that intangible part of one's being, the mind, we must recognize our responsibility and fulfil our obligations. For as McCoy[3] has stated: "In the competition of life, an individual is entitled to every advantage which is rightfully the heritage of nature. Given a reasonable degree of health and mental equipment, a growing child may cope effectually with its environment and develop traits and character patterns which make for success and happiness." Too frequently, the dentist considers only the loss of the physical structure of the tooth and fails to recognize the possible mental implications inherent in unsatisfactory treatment or lack of treatment.

That the incidence of trauma to anterior teeth is increasing among children is the opinion of many competent observers. Zander and Law,[4] Sweet[5] and others have alluded to the condition. Sweet has observed that "More than 90 per cent of all fractured anterior teeth protrude and do not have lip coverage."

Protruding anterior teeth must be recognized as the most important *predisposing factor* in injury to these teeth. Attention of the general practitioner as well as of the orthodontist should be focused on the prevention of this abnormality of the dental arch if the problem created by fractures of the anterior teeth is to be minimized.

One orthodontist,[6] in referring to the prevalence of fractured anterior teeth, writes: "Coronal fracture of one or more anterior teeth is so common in certain types of malocclusion, especially Class II Division 1

(Angle) that it may be regarded as one reason for the early treatment of this deformity." He continues: "In one hundred cases of this type, taken in routine order from treated cases in my collection, eleven were found to have fractured teeth." Indeed, we have seen cases in which orthodontic means were being used to correct protrusion and, while the appliances were in place, one or more of the protruding teeth had been traumatized. Lewis[7] concludes a study of the protrusion factor by observing, "there is a real relationship between the incidence of fractured anterior teeth and the protrusion of those teeth, a relationship which should not be ascribed to chance alone."

A long and intriguing list of *exciting causes* might be given as being responsible for the trauma. Only a few can be mentioned here. Accidents in the schoolyard predominate: while drinking at the fountain or from "pop" bottles, from thrown stones and falls on concrete walks and from bicycles, while at games and in fights. Young children at home receive injuries by falling against open dresser drawers, down steps and stairways and in rough and tumble play. Roller skating in the spring and ice skating in the fall and winter take a terrible toll of these prominent young teeth.

Within the past 20 years young people, many of them in the susceptible category, have become more and more active in vigorous contact sports. Protective mouth and face appliances are being worn by a few, but those people responsible for these sports should see that protective devices are worn routinely to prevent the injuries which otherwise will take place.

Standards for mouth protectors have been enunciated concisely by Sidney B. Finn[8] in *Clinical Pedodontics* as follows:

A mouth protector should meet the following standards:

(1) It should conform to the contour of the teeth and alveolar processes of the entire dental arch.
(2) It should not be so unusually bulky that it will interfere with normal breathing and speaking.
(3) It should not dislodge easily or be possible for it to be accidentally swallowed and lodged in the throat.
(4) In children, the material in contact with the hard and soft tissues should be pliable; the degree of pliability should be governed by the nature of the appliance and the type of contact sport.
(5) It should not impinge upon the soft tissues, especially the dental papillae, so as to cause irritation.
(6) It should not be uncomfortable to wear because of unequal stresses or high vertical dimension beyond comfortable limits.
(7) It should be relatively easy to construct and not too expensive.

Mass-produced standard-sized protectors are usually not very satisfactory. Custom-made protectors of rigid acrylic or nonrigid molded latex or velum rubber are more dependable and efficient and their construction is simple. Finn describes the technic in detail.

The sooner it is recognized that dental protection can be provided for participants in body contact sports, particularly among school children, the fewer will be the disfiguring dental injuries. Managers and organizers of such sports should make mouth protection mandatory for these young participants. Dentists

should be thoroughly conversant with the construction of these protective appliances.

A comprehensive report on the dental injuries received in high school athletics has been given by Kramer.[9]

He found that in one year, 1939–40, among 11,500 high school students, 691 sustained injuries at athletics which required the attention of a physician or a dentist. Twenty-seven per cent of these (i.e., 184) were dental injuries, including 104 broken teeth, 33 chipped teeth and 24 teeth knocked out and requiring replacement.

TABLE 1

School	No. of Children	Involvement			Type of District
		Teeth	Children	% of Children	
A	918	42	36	3.9	Excellent
B	345	26	22	6.4	Good
C	423	22	21	4.9	Good
D	635	29	25	3.9	Fair
E	235	14	12	5.1	Fair
F	1,200	48	42	3.5	Poor
G	495	24	20	4.0	Poor
Totals	4,251	205	178	4.2	

In a recent survey made in several of the secondary schools of a large city, some interesting figures were obtained concerning the *prevalence* of fractured teeth among a series of school children. Table 1 shows the record for seven schools in which 4,251 children were enrolled. It will be seen that 4.2 per cent of the children (178) had 205 fractured teeth. The ratio of boys to girls was 127:51. These figures are on the

conservative side because they do not include several possible classes of injuries to teeth, e.g., teeth that have been traumatized but show no fracture of structure and remain vital. The fractures were distributed in the anterior teeth in the following manner:

4	72	79	1
2	1	1	2
2	1	1	2
7	18	18	6

Sweet[5] reported that 90 per cent of all fractures to teeth occurred in the maxilla, but in our survey the incidence was 75 per cent in the maxilla and 25 per cent in the mandible.

The record of treatment rendered for the cases observed in this survey is discouraging. Many teeth in which the pulps had been involved at the time of accident had been neglected, and a state of non-vitality existed, with attendant discoloration, apical bone destruction and other complications. In too large a percentage of cases the child had consulted a dentist at the time of the accident and had been told by the dentist that he was too young for anything to be done yet and to wait until the age of 16 or 18. Perhaps such advice is the result of ignorance or uncertainty as to how to proceed.

Prevailing variations in treatment.—A few years ago McBride[10,11] and the members of the Children's Section of the Detroit Clinic Club distributed a questionnaire among a group of interested pedodontists, orthodontists and general practitioners throughout

the United States which included the following questions:

What is your method of treatment and restoration for the following cases:

1. Child, 8 years, maxillary central incisor, diagonal fracture not involving the pulp but close enough so that pulp shows pink through the dentin.
2. Child, 8 years, maxillary central incisor, lateral fracture with incisal half lost, pulp protruding from tooth.
3. Child, 8 years: (*a*) one maxillary central incisor lost, (*b*) two maxillary central incisors lost.

One hundred and twenty-five questionnaires were sent out and 61 replies were received, 49 of which contained definite methods of procedure. To question 1 there were 11 suggestions for temporary and five for permanent restorations. To question 2, five replies favored extraction of the tooth; five would cap the pulp; 12 recommended partial removal of the pulp, and 22 suggested complete removal of the pulp. There were 10 different types of temporary restorations recommended and five permanent. To question 3, the divergence of opinion was as great as in the other instances.

When considering the reasons for such wide variations of opinion one must recognize certain variable factors such as the wishes of the patient and the parent with respect to the appearance of the restoration, the ability of the patient or parent to meet the financial obligation incurred and the child's physical condition. Nevertheless when these and other factors are all accounted for, inexperience on the part of the dentist and uncertainty as to the best method of pro-

cedure probably are the important reasons for the variations.

Complete unanimity of opinion on the treatment for these cases is hardly expected, but some semblance of standardization of procedure seems desirable if the general practitioner is to give his utmost in service for these unfortunate children.

As a necessary preliminary to standardization of treatment, some all-inclusive classification of the types of cases which will occur is desirable. As Kennedy[12] so well expressed it: "No branch of dentistry has progressed rapidly until cases have been classified. As a proof of this, we have only to look at the kindred subject, orthodontia, and realize that before the time when Dr. Angle presented his classification, cases were handled in a rule-of-thumb manner, with varying results." Classifications limited to cases in which some tooth structure is lost are given by Sweet,[5] McBride,[11] Hogeboom[13] and Kronfeld.[14] A more extensive classification is suggested by Adams[15] and Brauer,[2] who include, besides fractures, all the instances of trauma without fracture.

The classification given in Table 2 is suggested as being all-inclusive, and will serve as the basis for standardization of treatment. A diagrammatic outline of the classification is shown in Figure 1.

Subsequent chapters outlining treatment will be based on this classification so as to facilitate the use of this manual for ready reference. Each class will be considered as a separate entity, with a concise prescription for treatment set forth at the beginning of

the chapter, followed by a more detailed description of various phases and technics in carrying out the prescription plan. As far as possible, illustrations are included to impress on the mind of the reader the thoughts intended. To encourage further reading on the subjects under discussion, a bibliography is included at the end of each chapter.

Before entering on a consideration of each class, there are some factors which might be considered common to all classes.

Recording the history.—A brief but careful case history and the results of clinical examination should be recorded for each case.

The history should include: (1) name, address and telephone number of the patient; (2) age; (3) when accident occurred; (4) how accident happened; (5) any previous accident to these or other teeth; (6) patient's complaints, e.g., (*a*) sore to touch, (*b*) pain on biting, and (*c*) reaction to thermal changes.

Clinical examination includes the following: (1) type of abnormality, (*a*) fracture of crown, (*b*) displacement of tooth, (*c*) loss of tooth, (*d*) laceration of tissues and swelling; (2) reaction to percussion; (3) transillumination examination for congestion; (4) mobility; (5) vitality reaction; (6) occlusion in centric and functional positions; (7) radiographic examination of the teeth involved.

Radiographic examination should be advised in every case for several reasons: (1) to determine the proximity and size of the pulp in relation to lost crown structure; (2) to determine the stage of development

TABLE 2.—CLASSIFICATION OF TRAUMATIZED ANTERIOR TEETH

Class 1

Simple fracture of the crown—involving little or no dentin

Class 2

Extensive fracture of the crown—involving considerable dentin, but not the dental pulp

Class 3

Extensive fracture of the crown—involving considerable dentin and exposing the dental pulp

Class 4

The traumatized tooth which becomes nonvital—with or without loss of crown structure

Class 5

Teeth lost as result of trauma

Class 6

Fracture of the root—with or without loss of crown structure

Class 7

Displacement of a tooth—without fracture of crown or root

Class 8

Fracture of the crown en masse and its replacement

Class 9

Traumatic injuries to deciduous teeth

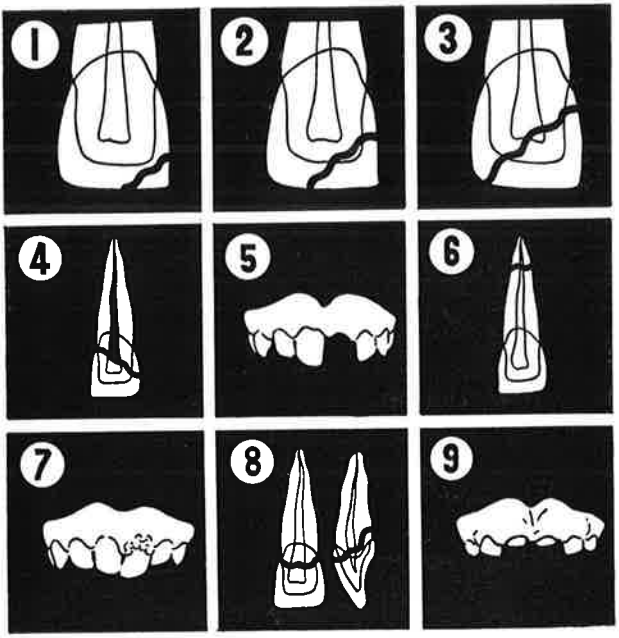


FIG. 1.—Diagram of classification of traumatized anterior teeth.

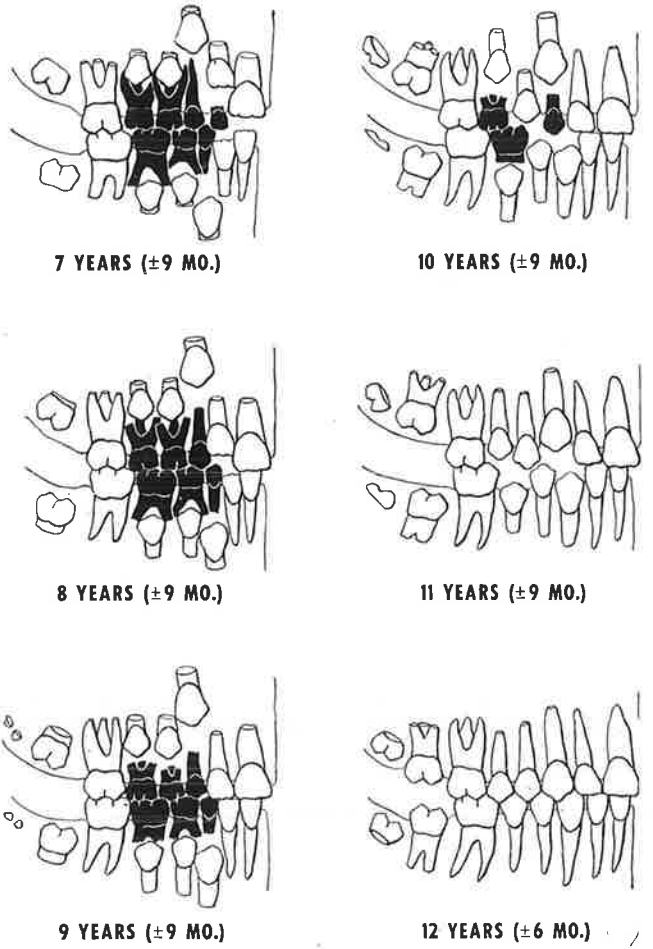


FIG. 2.—Development of human dentition at age 7–12 years. (Courtesy of Dr. I. Schour and Dr. M. Massler.)

of the root apex, if it is not complete; (3) to determine whether a root fracture complicates the case; (4) to provide a record for comparison with future radiograms.

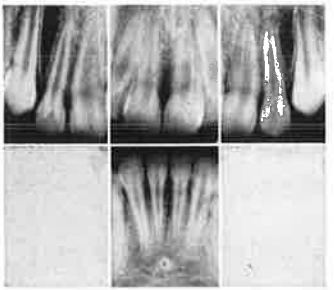
When considering the treatment recommended for traumatized teeth, the question of age is of great importance. If the patient's chronologic and physiologic ages correspond, one should be able to visualize the stage of development of the anterior teeth immediately. Schour and Massler have given a series of diagrams of the average normal in the stages of development at various ages (Fig. 2).

Growth and development.—From our records we submit radiograms of anterior teeth of patients aged 7½, 9, 10½ and 12 years, illustrating the development of the roots of the anterior teeth at the ages during which a large percentage of these accidents occur (Fig. 3).

The stage of development attained at the time of injury influences the prognosis. The young undeveloped tooth, in which the root apex is wide open and funnel-shaped and the developmental sac is still in evidence, has extraordinary vitality and recuperative powers. The circulatory disturbances which attend the shock to the pulp following injury are compensated for by the large apical passageway for the engorged blood vessels. On the other hand, when apical development has reached a more advanced state of maturity and the passageway through the apex is narrow, strangulation of the engorged vessels is probable and congestion of the pulp tissues ulti-

Age 7½ years

Age 9 years



Age 10½ years

Age 12 years

FIG. 3.—Normal anatomy of root and pulp development of anterior teeth at various ages.

mately leads to necrosis. Fortunately, all normal factors in development seem designed to aid man in his attempts to maintain the normal. The closed apical foramen may increase the likelihood of pulp strangulation but enhances the chances of success with root canal therapy, whereas in the undeveloped tooth with its open apical foramen, the prognosis for maintenance of a normal healthy pulp is good but for successful root canal therapy is poor. One is impressed more and more with the wisdom of a good Providence.

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CHAPTER 2 CLASS 1

Simple Fracture of Crown—Involving Little or No Dentin

Prescription for Treatment

A. Record case history (p. 25)
B. Record results of clinical examination (p. 25)
C. Emergency treatment
    1. Smooth edges
    2. Apply coat of protecting varnish
    3. Advise patient to report in one week for observation
    4. Continued thermal reactions require more extensive emergency treatment (see Chap. 3)
D. Recall in 6–8 weeks unless pain in the meantime (repeat tests and radiograms)
   Decide whether permanent restoration is to be done now or later
E. Permanent restoration
    1. Improvement of esthetics by grinding and disking
    2. Restoration with gold foil
    3. Restoration with gold pin inlay, with or without plastic veneer
    4. Restoration with porcelain or plastic inlay

THE PRELIMINARY procedures of taking and recording the history and making the clinical examination, discussed in Chapter 1, are routine not only for class 1 but for all cases.

In the class 1 type of case, shown in the diagram (p. 31), the position and amount of tooth structure lost may vary. Furthermore, in class 1 should be included the tooth which is traumatized but not displaced and in which no visible structure is lost.

Shock and its effect on the pulp.—A tooth that merely receives a blow may not be looked on as being seriously affected. Discomfort is slight at the time and soon disappears. The patient probably does not consult a dentist; and if he did, there is little that the dentist could do for him. At this stage it is well to sound a warning concerning any expressions of assurance regarding a favorable prognosis for such a tooth. Despite the apparently minor nature of the disturbance to the tooth, there is no means of diagnosing the pulp reactions to the shock to which it was subjected, nor can one forecast accurately the future of the pulp.

Box[1] believes that "an injury to the pericementum from a blow on the tooth is often manifested in the pulp as a direct arterial hyperaemia. If the blow has been severe, the capillary anastomoses at the periphery of the pulp are not adequate to carry on the circulation, a pathological hyperaemia results, followed by death of the organ through infarction." It is generally agreed that the walls of the capillaries within the dental pulp are often only the thickness of a single

endothelial layer, and these delicate walls may rupture readily when they are subjected to a severe blow.

Clinical observations suggest that the tooth which is traumatized but not fractured receives a greater degree of shock than the tooth which is traumatized and also fractured. The explanation for such a phenomenon might well be that the energy expended in causing cleavage of tooth structure is not transmitted to the tooth and its internal or surrounding structures as a whole; i.e., the break acts as a shock absorber.

The extent of structure lost in class 1 cases is limited to enamel or, at the extreme, includes only a small portion of dentin. The dentin may be exposed as the result of cleavage of the enamel along the dentinoenamel junction or may be included in the fracture. In the former instance, the exposed area is usually more sensitive to thermal changes and chemical irritations from mouth fluids than in the latter.

The outline of structure lost varies in each case. In the majority, it includes the mesial-incisal angle, while in a few it is limited to the middle third or middle lobe of the incisal edge. In the latter type, more of the lingual plate is involved than of the labial enamel plate.

The plan of treatment suggested for these cases may be divided into emergency or immediate treatment and subsequent treatment.

Emergency or Immediate Treatment

If the patient is seen within a few hours of the accident, immediate treatment is limited to eliminating the rough sharp edges of enamel which abrade the

tongue, using a disk or fine stone but avoiding heat, and protecting the exposed dentin with an application of varnish. One or two applications may be made and dried on. The object at this initial stage is to avoid unnecessary manipulation so that no further irritation is added to the already presumably shocked pulp.

The protective film of varnish will not last indefinitely, but it is reasonable to expect that by the time it is lost, the pulp will have recovered sufficiently from the stage of shock so that most normal oral stimuli will have little or no effect. Nevertheless the patient and his parents should be warned that if discomfort is experienced during the following week, the dentist should be informed without delay. The immediate treatment in cases in which pain continues is considered in the discussion of the class 2 group in Chapter 3.

In most instances, no further discomfort is experienced after immediate treatment. From extensive clinical observation on several hundred cases the author believes that the six to eight week period following the accident constitutes the *critical recovery interval* for the pulp. A pulp which survives that period and is in a healthy state, as shown by the all-too-inadequate methods of testing its vitality, has a reasonably good prognosis for the immediate future at least. What the long range prognosis is cannot be stated with any measure of accuracy. A slow insidious degenerative process may be initiated by the accident which will run its course for years before it becomes manifest.

Suffice it to say that after a successful waiting period

of six to eight weeks the patient should be recalled and further correction of the defect considered.

Further tests should be made periodically during the ensuing year to be sure that the pulp is vital. There is an inclination in practice to forget to check these teeth. The parents should be warned to check for color change in the crown.

Permanent Restoration

At this point it should be noted that many patients with class 1 cases do not present themselves for dental advice or treatment at the time of the accident. It is during the course of a routine examination that note may be made of a small defect on a front tooth (the result of an accident) which has been present for years and of little concern to the patient from the esthetic standpoint. Esthetic reasons, therefore, do not always demand the restoration of lost tooth structure in these cases. However, there are some cases in which the demand for treatment is based entirely on esthetic requirements.

Replacement of a small fragment of enamel and its supporting dentin by artificial means presents some intricate problems. Among them are the means to be employed for providing retention for the restoration and the selection of a material which will fulfil the requirements of strength and esthetics in the restoration.

Correction by grinding.—It is logical to find that judicious grinding and disking to smooth the edges and restore a semblance of the normal contours is most expeditious in these cases. The grinding may be

accomplished slowly by doing a little, at intervals, during three or four months. This adjustment by grinding should be carried to the adjacent teeth as required for purposes of maintaining symmetry in the natural tooth lines. Great care must be exercised in the grinding of these immature teeth.[2-4] The ground surfaces should be highly polished with fine disks, and the areas so treated should be varnished before the patient is dismissed. Little or no discomfort is experienced by the patient when such care is exercised. Figures 4 and 5 show a case before and after grinding. The case in which the middle lobe of the incisal edge is chipped out and the angles are left intact is almost invariably corrected in this manner. However, when the mesial angle is involved, correction by grinding is more difficult. The mesial incisal angle of the central incisor is square, whereas the distal incisal angle is rounded. To re-establish the square mesial angle, when a portion is lost, more grinding is involved. The loss of structure at the distal angle is corrected simply by increasing the degree of roundness of the angle with little or no deterioration of the esthetic requirements, whereas such a correction at the mesial angle would detract greatly from the appearance.

When the extent of the structure lost or the shape of the fracture line or the patient's demand calls for a restoration in a class 1 case, there is a choice of one of three or four materials. It is difficult to fulfil all the ideals with any one material.

Restoration with gold foil.—Restoration with gold

foil is perhaps the most direct and satisfactory method from the standpoint of retention and a minimum of cavity preparation. The esthetic effect of gold foil,

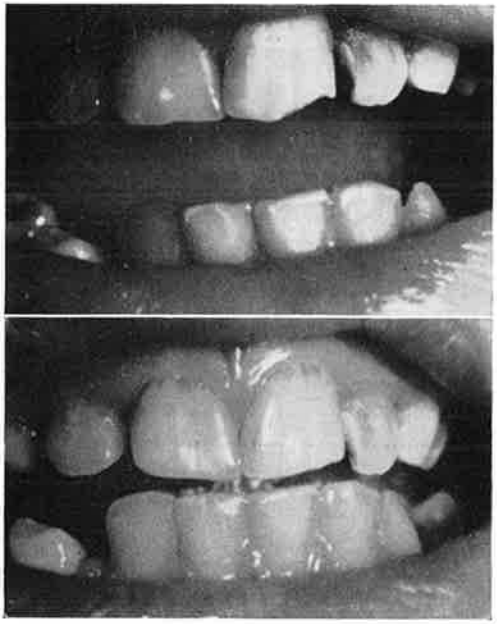

FIG. 4 *(top)*.—Class 1 fracture of the maxillary left central incisor.
FIG. 5 *(bottom)*.—Same case, after adjustment by grinding.

though not wholly displeasing, is not in harmony with natural tooth colors, and for this reason some patients object strenuously to its use in a prominent position in the mouth. The age at which a foil restoration can be inserted places a further limitation on its early use.

McGehee,[5] speaking of the age at which gold foil might be used in the teeth of children, states: "No fixed rule as to age can be given; in some children gold may be used at ten years of age; in others not

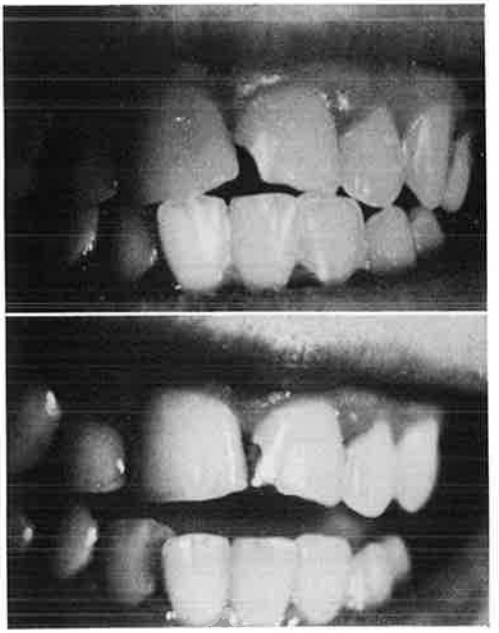

FIG. 6.—Class 1 fracture before and after restoration with gold foil.

until much later." Black[6] refers to the use of gold foil in children's teeth thus: "Gold foil is particularly desirable for children past 10 or 12 years of age." Therefore we feel sure that the use of foil is justified in class 1 cases soon after the apical portion of the

root is completely developed, provided normal development of the surrounding structures is unquestionably in evidence.

Restoration with a pin inlay.—The use of a pin inlay in the restoration of a fractured tooth of this type has many advantages.

The direction of the path of insertion of the inlay is first decided. If we are dealing with a co-operative

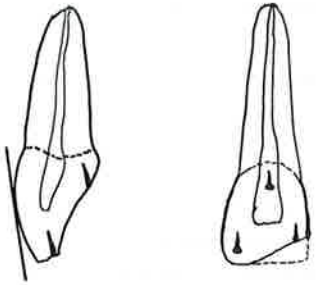

FIG. 7 *(left).*—A guide pin is attached to the labial surface for establishing direction of pins.
FIG. 8 *(right).*—The position of the three pins.

child, a guide pin is attached to the labial surface of the tooth with sticky wax (Fig. 7). A removable guide, made on a study cast, is used for the child who is difficult to handle. The direction of the path of insertion should be parallel to the middle labial third of the tooth when viewed from the mesial or distal aspect and in the direction of the long axis of the tooth when viewed from the labial aspect.

In most cases little preparation of the lingual surface is necessary, just sufficient to permit the use of gold of

about 24 gauge thickness. The slice should be made at the expense of the lingual part of the proximal surface. Only the thickness of a lightning disk should be shown at the labial surface.

Seats for the pins are made with a tapered diamond point about the size of a no. 702 tapered fissure bur. The incisal seats should be placed well out toward the proximal margin and should merge with the lingual portion of the slice. The cingulum seat should always be as far gingivally as possible.

A 23 gauge twist drill or a no. ½ round bur is used to taper the hole. The arrangement of the pins is seen in Figure 8.

Where plastic pins are used in taking the impression, the make of the bur must be considered. Different manufacturers make burs which vary greatly in diameter. When the bur is found to be larger than the pin, an amount sufficient to compensate for the difference must be removed from the small end of the pin. On the other hand, if the pin is larger than the bur, part of the bur must be removed. By using a small piece of clear plastic it is not difficult to determine when the fit is correct.

If an open-faced inlay is to be used—one with a window from labial to lingual surface to be filled with plastic—the semidirect impression method is best. The labial contour, the incisal length and contact points are recorded in the wax pattern.

For waxing the investment model, 24 gauge wax is used on the proximal, incisal and lingual surfaces. Acrylic retention may be provided by placing small

pieces of Nylon bristle into the wax in suitable locations. Nylon will burn out like wax.

Special care is required in cementing pin inlays. Cement should first be placed in the base of the pin holes, using cement tubes which are made for the purpose and sold by supply houses.

Self-curing acrylic may be used in the window, since its only function is esthetic.

Restoration with porcelain or plastic inlay.—A fused porcelain or natural color plastic (acrylic) inlay must also be considered for the class 1 restoration. A harmonious effect can be obtained with these materials, but not to the extent that detection of the artificial restoration is impossible. Indeed, a mediocre restoration with either of these materials is more displeasing than one with gold. A great deal of painstaking care and considerable skill must be exercised in the construction of these restorations and especially in the cementation process. Many good restorations with these materials have been ruined in this final stage.

FIG. 9.—Pin retention and loop reinforcement in porcelain or plastic inlay.

Retention for these inlays is dependent on pins, with some form of reinforcing loop processed through the inlay (Fig. 9).

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CHAPTER 3 CLASS 2

Extensive Fracture of Crown—Involving Considerable Dentin but Not the Pulp

Prescription for Treatment

A. Record case history (p. 25)
B. Record results of clinical examination (p. 25)
C. Emergency treatment for the average case
   1. Wash off fractured tooth with tepid sterile water on sterile cotton
   2. Isolate the tooth and dry
   3. No strong irritating drugs should be used on the dentin
   4. Cover dentin with a creamy paste of calcium hydroxide mixed with sterile water or anesthetic solution
   5. Avoid pressure at all stages of the procedure
   6. Cover hardened capping material and enamel exposed in the fracture with a rapid-setting, nonirritating cement
   7. Instruct the patient: the cement covering will be lost in 24–48 hours; discomfort may follow loss of cement covering; discomfort should disappear in a few days; if not comfortable in 7 days, report for treatment. Follow as described in D.

D. Emergency treatment for the case with near exposure 1–6. Same as C, 1–6.
   7. Clean all surfaces of the tooth
   8. Select resin crown form of suitable size and shape; contour on gingival end to fit without impingement on gingival tissues
   9. Modify crown form with self-curing plastic of suitable shade to create an accurate treatment crown
   10. Check bite registrations and perforate labial face with a no. 9 round bur to provide for application of pulp tester
   11. Fill crown form with creamy mix of cement and seat to place over the tooth
   12. Again check bite in all positions
   13. Advise the patient to report at once if pain is experienced

E. Allow a rest period of 6–8 weeks. Then, if clinical examination is satisfactory and radiographic evidence is negative, two alternatives exist
   1. In the average case which has been left uncovered in the emergency phase, place a permanent restoration
   2. In the near exposure case, place a temporary permanent restoration, such as a gold acrylic cap

F. In the near exposure case, at a suitable time in the future place a more permanent restoration, such as a porcelain jacket crown

General Considerations

The cases of broken anterior teeth which fall into this class make up at least 60–70 per cent of all those presented for treatment. Perhaps the reason for this high percentage is that many cases which fall into class 1

are not seen in the dental office at the time of the injury because of their minor nature. Also, since the area of dentin opened up is greater in class 2 cases, the symptoms are more severe and relief is sought.

The commonest symptoms described by the patient are those of thermal shock and pain from pressure of food on the sensitive dentin, which may be so thin that the pulp outline is indicated by a pink color, transmitted through the film of remaining dentin.

There is certain information which it is well to obtain before proceeding with emergency treatment. After an accurate history is taken, with special attention to the age of the patient and an account of the reactions of the tooth since injury, a radiogram is made. The radiogram is required for the reasons mentioned in Chapter 1 and repeated here because of their importance: (1) to determine the proximity and size of the pulp in relation to lost crown structure; (2) to determine the stage of development of the root apex, if it is not complete; (3) to determine whether a root fracture complicates the case; (4) to provide a record for comparison with future radiograms.

The reactions of the tooth to vitality tests and the results of percussion tests should be recorded. No response to the vitality tests at this time is only an indication of the degree of shock which the pulp has suffered and must not be interpreted as indicating probable death of the pulp. Examination of the injured tooth with the transillumination lamp is also useful when compared with observations on the adjacent normal tooth. The extent of the early state of conges-

tion which will be revealed by this means must be considered when determining the prognosis for the injured tooth.

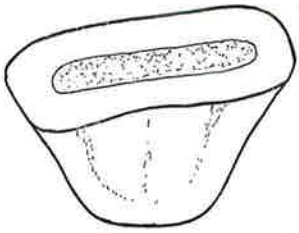
Emergency Treatment

The objective of emergency treatment is reduction of the hyperemia of the pulp which follows the initial shock and the protection of the pulp against further irritation. The ability of the pulp to survive the initial circulatory disturbances is greatly influenced by the size of the opening at the apex of the root. When the root is not completely developed and the foramen is large, there is less likelihood of strangulation of the pulp. When the foramen is large, it is imperative that the pulp be kept alive so that normal development of the root may be completed.

Every phase of the emergency treatment must be nonirritating to the pulp: hence no strong irritating drugs should be used on the exposed dentin. The exposed dentin is washed with sterile tepid normal saline solution or distilled water to remove any debris. The tooth is isolated and the dentin dried, without cauterizing it with irritating caustics.[1]

The dentin is then covered by a thin mix of calcium hydroxide. This paste is more satisfactory if it is capable of setting rapidly after being placed on tooth structure. Berk[2] advocates mixing calcium hydroxide with an aqueous solution of methyl cellulose to create a tenacious paste; it is easy to manipulate and is cohesive and adhesive. He observes: "The methyl cellulose seems to enhance the beneficial effects of the cal-

cium hydroxide." A thin mix of capping paste is placed on the dentin with a carrier made from a discarded smooth broach (pathfinder), the point of which is bent to form a loop 1 mm. in diameter. When the capping paste has hardened sufficiently so that any excess may be carved away, a thin mix of a fast-setting temporary cement is placed over the capping paste and



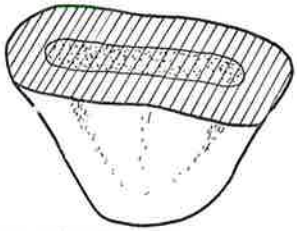


FIG. 10 *(left)*.—Capping paste over the dentin in a class 2 fracture.

FIG. 11 *(right)*.—Same case. Cement covering the capping paste and enamel.

out over the enamel exposed by the fracture (Figs. 10 and 11). The capping paste and the cement must be of thin consistency in order to be sure that no pressure is exerted on the thin elastic dentin membrane overlying the vital pulp.

Two alternatives must be considered at this stage. In the average class 2 case, we may decide to proceed no further with the emergency treatment except to warn the patient and the parent that within 24–48 hours, the cement covering will be lost and sensation to heat and cold will become marked. This should gradually subside and be barely noticeable in about seven days.

Crook[3] believes that young dentin left open in this way exposes tubules to the invasion of microorganisms, and to prevent this he recommends treatment of the exposed dentin "by impregnation of the dried dentin cross section" with 40% zinc chloride applied to the dentin and precipitated with 20% potassium ferrous cyanide. This is applied repeatedly until no pain is felt to cold." He then adds that "Under no circumstances should a crown of any type be put on such a fractured tooth for a considerable length of time." The danger of drug irritation in this form of treatment should not be underestimated. J. F. Howell,[4] dealing with this matter, states that "protoplasmic poisons hinder rather than help."

The second alternative, to be used when providing emergency treatment in cases with a near exposure and for those cases which persist in reacting painfully to thermal changes after seven days, is to cement a crown form or metal cap over the tooth.

After placement of the capping paste and the cement, a suitable resin crown form is selected, preferably slightly on the large size, and its gingival end is contoured to fit over the fractured crown without impingement on the gingival tissues. Centric occlusion, functional positions and the incisal bite are checked with the empty crown form in place on the tooth. Very slight adjustment may have to be made for these positions by reducing the incisal edge of either the injured tooth or the opposing tooth.

The fitted crown form is half filled with self-curing acrylic, carefully chosen for shade, and is seated on the fractured tooth for two minutes and no more. It is

removed from the tooth and allowed to set, out of the mouth. This will take approximately five minutes. Never leave it to cure completely on the tooth, because the heat produced may irritate the pulp. The excess plastic is trimmed from the periphery of the crown

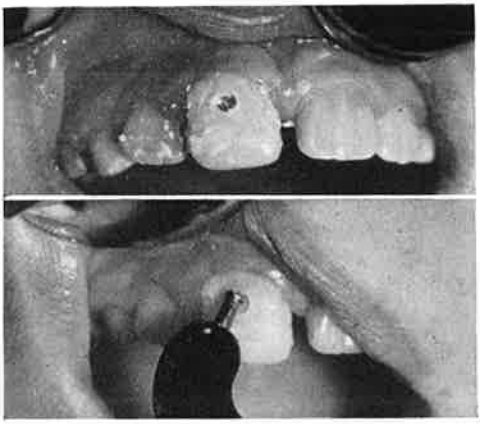


FIG. 12 *(top).*—Emergency treatment crown showing labial opening.

FIG. 13 *(bottom).*—Emergency treatment crown showing pulp tester terminal in contact with the tooth.

(Courtesy of Dr. J. B. Pepper.)

form. With a no. 9 round bur an opening is established through the labial face of the plastic crown. This perforation should be placed in such a position that the sound enamel will permit testing of the vitality of the pulp without removal of the treatment crown (Figs. 12 and 13).

This plastic crown is cemented in place with oxyphosphate cement. A hole may be put through one

incisal corner to allow it to be seated accurately without pressure and to allow escape of the excess cement. After it is set hard, the excess is cleaned off. The bite is then checked again. To leave the injured tooth in heavy occlusion may overload the periodontal tissues.

When both maxillary central incisors or a central and a lateral incisor in the same arch are fractured, the two crowns may be joined together by opening the contact point of the resin crown forms and permitting the self-curing plastic to fuse the crowns into one unit. This overcomes the difficulty occasionally encountered in providing retention for treatment crowns. Occasionally a single treatment crown which is difficult to keep in place for the required eight to 10 weeks is fused to a plastic crown prepared for the adjacent intact tooth.

Multiple fractures of mandibular anterior teeth may be protected with treatment crowns made as one unit and ligated to the incisor teeth with ligature wire.

Just before one dismisses the patient after the emergency treatment, two points must be discussed with the parent or patient. First, explain that no matter what treatment has been given and despite anything that can be done, the nerve in the tooth may become nonvital because of the shock it has received. Therefore, if pain is experienced before the next appointment, the patient should report at once for a further examination. Second, six to eight weeks should pass before anything further is attempted. This *waiting period* between the emergency treatment and subsequent treatment is definite and important. It is supported by considerable clinical evidence and by the observations of other investigators.[5]

FIG. 14 *(top left).*—Maxillary left central incisor with class 2 fracture, given emergency treatment Oct. 6, 1942.

FIG. 15 *(top right).*—Same case, 7 weeks later. Note radiolucent areas at apexes of both centrals. Reactions to vitality tests were negative.

FIG. 16 *(bottom).*—Same case, March, 1946. Note disappearance of radiolucent areas.

From the many cases recorded and retained under observation, several examples might be presented in which subsequent examination six to eight weeks later revealed the pulp to have lost all its vitality and yet no symptoms of pain or discomfort had been

experienced. In such cases it must be assumed that we intercepted a possible cause for widespread apical bone destruction and rendered successful root treatment at the optimal time (Figs. 14-16). However, in most of these class 2 cases the pulp is found to be vital and normal after the waiting period, and our clinical observations support the impression that they will remain so and in a satisfactory and healthy condition for an undetermined period of time.

At the second appointment, i.e., the recall appointment, six to eight weeks after the emergency treatment, percussion, vitality and mobility tests, examination with the transillumination lamp and a radiographic examination should be made carefully. The treatment crown does not need to be removed. The labial perforation (Figs. 12 and 13) permits the pulp tester to be applied to the labial enamel. Even though a positive reaction to the vitality test is recorded at this stage, the exact status of the dental pulp is still open to question. A condition of vitality may exist as indicated by the tests; but what is the prognosis for that pulp? Perhaps the answer is more appropriately linked with the state of the circulation within the pulp. One form of slow degeneration which takes place within the pulp of an injured tooth over a period of years is calcific in nature. Such a condition manifests itself in the partial or complete obliteration of the pulp chamber, seen on radiographic examination (Fig. 17).

Some patients with the class 2 type of injury never receive emergency treatment because a dentist is not consulted at the time of injury. The patient puts

FIG. 17.—Traumatized mandibular left central incisor with partial obliteration of the calcified pulp chamber. *Left*, radiogram taken at the time of the accident in 1935; *right*, 1940.

FIG. 18.—Maxillary central incisors of boy, 12, showing normal development of the left but interference with development of the right central since trauma at 9½.

up with pain for a few days, but it gradually subsides and subsequently the tooth is comfortable. The stimuli reaching the pulp through open dentin in such a case are fairly intense, but if they are not of the magnitude to cause necrosis of the pulp, they may be responsible for activation of the natural protective

FIG. 19 *(left).*—Left maxillary central incisor which had been covered for several years.

FIG. 20 *(right).*—Right maxillary central incisor, fractured at same time as left incisor (Fig. 19). Compare size of pulp chamber in these two teeth.

(Courtesy of Dr. J. B. Pepper.)

mechanism which results in secondary dentin formation. This is the basic principle which operates when no cap and band are placed to retain the cement covering in the emergency treatment described above for the average case. When the tooth is protected as outlined in the emergency treatment phase described for the near exposure case, these stimuli are reduced. The extent to which the pulp recedes in the crown of the normal tooth as the result of natural growth processes is illustrated in Figure 18.

Admittedly, it is virtually impossible to compare development in the tooth which is protected immediately after it is subjected to a class 2 fracture with that in a similar tooth which is not protected. Figure 19 is a radiogram of a left central incisor which was fractured and completely covered with a treatment crown for five years. Figure 20 shows the right central incisor in the same mouth, which was fractured at the same time. No treatment crown was used. The greatly increased recession of the right central incisor, compared with the left, illustrates the effect of normal stimuli on protection of the pulp.

With the relatively large portion of tooth structure lost in class 2 cases, another factor besides esthetics and the need for protection of the pulp enters into the consideration of the pro's and con's of use of a restoration rather than prolonged watchful waiting. It might be called the space-maintenance factor. We are aware of what happens when a tooth is lost and no replacement is made; the space closes by virtue of movement of the adjacent teeth. Similarly, if the contact point is lost as the result of fracture of a portion of the crown, the adjacent teeth are free to move and some of the space for the crown of the tooth may be lost. Two types of such movement are presented in Figures 21 and 22.

Spring[6] summarizes his observations on fractured incisors with the words "Lack of treatment of fractured incisors may result in speech defects, a psychological impact resulting in an inferiority complex, a loss of space due to loss of contact, and an increased susceptibility to caries in the fractured tooth."

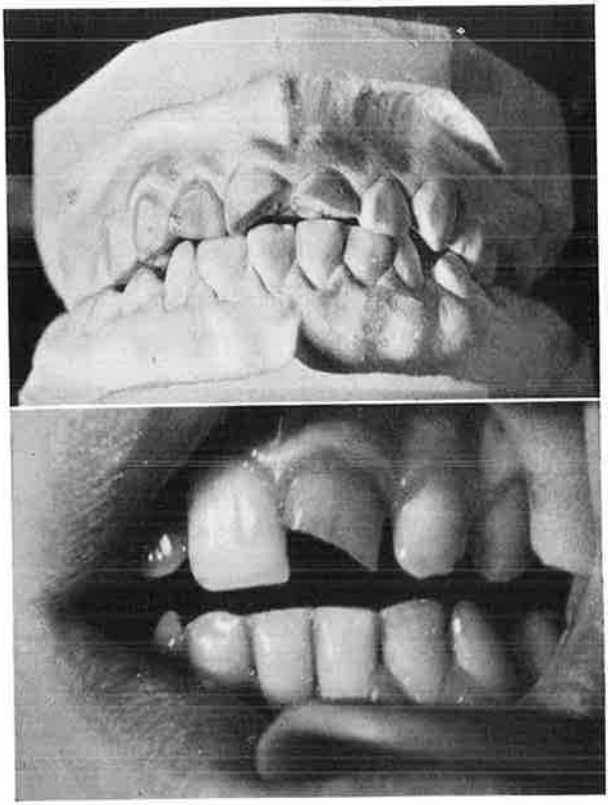


FIG. 21 *(top).*—Lingual movement of the fractured maxillary left central and labial movement of the unsupported mandibular left central incisor render placement of a restoration on the fractured tooth a difficult operation.

FIG. 22 *(bottom).*—Tipping and drifting of a fractured tooth complicates restoration of the lost structure.

The Temporary-Permanent Restoration

The evidence just presented seems to support the contention that protection of the remaining tooth structure and restoration of the lost portions is desirable in most class 2 cases. After successful emergency treatment, the restoration to be advised and constructed must be considered of a temporary-permanent character. Elaboration of the term "temporary-permanent" may not be out of place here. Foremost in the dentist's mind is the fact that he is dealing with a young tooth in which the full development of both the crown and the root is not complete. The coronal pulp is large and seems to occupy most of the crown, with little dentin separating it from the enamel, and even this dentin is young and immature.[7,8] These factors add greatly to the dangers of extensive preparation of the tooth for a restoration. Therefore, to minimize the danger of adding further injury to the pulp at this stage, a compromise is justifiable and a restoration of a temporary nature is made, the preparation for which is reduced to a minimum. However, the term "temporary" usually implies a brief period, such as a few weeks or months at the most. The restoration to be prepared at this time, if it is to be satisfactory and fulfil the requirements of the case, must withstand functional use until the time when it is thought advisable and safe to prepare the tooth for a restoration of greater permanency. The interval which must elapse between the placement of the "temporary-permanent" restoration and the placement

of the ultimate restoration may vary from five to 10 years, depending on the patient's age at the time of the injury and the rapidity with which the tooth arrives at a more mature state. Therefore we believe that the restoration which is to be made now, although it is temporary, must have some degree of permanence, and hence the term "temporary-permanent." The temporary-permanent crown described here may also be called a treatment crown.

The importance of the esthetic requirements of this temporary-permanent restoration cannot be overrated. These patients are passing through the years when mental and social developments are important, and the characteristics molded at this stage will influence their lives in the future.

If, then, we take cognizance of all the factors mentioned, as we direct our attention to a satisfactory type of restoration for the class 2 case we will find that the choice is limited to the following means.

Basket clasp inlay restoration.—This type of restoration is similar in many respects to the regular three-quarter cast gold crown, with a silicate or plastic (acrylic) facing. Figure 23 shows a mirror view of the lingual surface of the inlay in place and a direct view of the labial surface, with the outline of gold and a silicate facing restoring the lost labial surface.

A slice off both proximal surfaces is required, but only enough to parallel these surfaces and allow sufficient thickness for that portion of the restoration covering the proximal surfaces. The incisal edge may be

reduced slightly with a no. 11 stone to provide for incisal protection in the inlay. Reduction of the enamel thickness on the lingual surface may or may not be required, depending on the nature of the centric and functional bite positions. The amount removed from the lingual surface will be limited to the needs of the

FIG. 23.—A basket clasp restoration.

case as indicated by the bite registrations. In most cases no preparation of the lingual surface is required.

Instead of grooves on the mesial and distal surfaces, commonly used in the three-quarter crown preparation, the opposite type of formation is used for retention in the basket clasp inlay (Fig. 24).

It will be recognized that the labial half of the proximal surface bevel will increase the extent of visible gold, but this is a compromise made to reduce the hazards attached to cutting grooves in the young tooth.

The impression for this preparation draws in the incisal direction as in the case of the three-quarter crown. The hydrocolloid impression technic may be used to advantage. The technic of construction after the preparation is complete is similar to that employed for any type of inlay. The gold used should be strong in thin areas, preferably a hard gold. If a silicious cement is the material of choice for the labial veneer, it

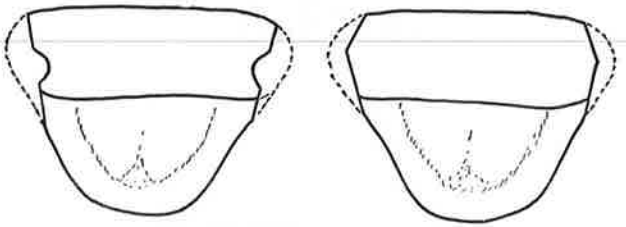


FIG. 24. — *Left,* three-quarter crown. *Right,* basket clasp preparation.

is placed after the inlay is polished and cemented. If plastic material (acrylic) is to be used as the labial veneer, the area prepared to receive it must have bulk. These restorations are satisfactory. Their disadvantages lie in the extent of visible gold and the difficulty experienced in selecting the shade of the veneer and maintaining its original tone, especially when it is backed up with gold.

As an opacifier over gold, use self-curing resin stains which are close in shade to the resin used for the veneer.

The gold-acrylic crown.—This crown might be described as an open-faced gold crown with an acrylic

veneer restoring the lost labial enamel. It combines the strength of gold for the lingual and proximal aspects of the crown, the retention provided by a continuous gold band at the gingival and the esthetics of the acrylic veneer. It protects the dentin which has been exposed by fracture from excessive irritation which might not be tolerated by the pulp and yet it permits normal stimuli to operate through the remaining labial enamel, thereby activating normal development and recession of the pulp.

Preparation of the tooth for this crown is held to a minimum. It may vary slightly according to the age of the child. First, in the 7–12 year old child, there are two steps in the preparation of the fractured tooth for a gold-acrylic crown. These are (1) reduce the mesial and distal walls to accommodate the gold to be used. It is essential to re-establish the original mesiodistal width of the fractured tooth for esthetic and functional reasons. If the adjacent central incisor is intact, measure its mesiodistal width and use it as a guide. Then (2) relieve the incisal edge and the cingulum to provide for the thickness of the gold, so that when the tooth erupts fully, it will be in proper occlusion. Traumatic occlusion may further injure the injured tooth, damage the opposing tooth and even cause recession of the labial gingival about the opposing tooth. Second, if the patient is beyond age 12 we can assume that some recession of the pulp and some maturity of the dentin are present. Age alone, however, is not the sole determining factor; therefore, the radiogram should be used as a guide before a more radical preparation is

employed. When indicated, a modified three-quarter crown may be used. A minimum of visible gold on each proximal surface is provided by preparing the mesial and distal aspects in accordance with the diagram in Figure 25. Both proximal surfaces should be made parallel or slightly divergent toward the incisal edge (Fig. 26). The portions of the incisal edge which may still be intact must be reduced to provide reasonable pro-

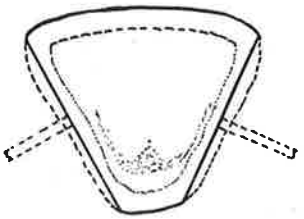


FIG. 25.—Direction of mesial and distal surfaces to minimize visible gold in finished crown.

tective thickness of the crown over the incisal edge. The centric bite must be checked (Fig. 27) and clearance provided, preferably by reducing the incisal edge of the opposing incisor tooth. However, reduction is not often required because anterior teeth in cases of fracture are seldom in contact in the centric position. Shallow proximal grooves for retention may be augmented with accessory pin anchorage at the cingulum.

The full indirect technic for the construction of both the gold-acrylic crown with labial strap or the three-quarter crown is recommended. The impression of the prepared tooth may be obtained either with the standard impression compound technic or the hydrocolloid

technic. Recently, the greatest degree of accuracy has been obtained with the latter method which is described in some detail here. The armamentarium required includes one of the dependable makes of hydro-

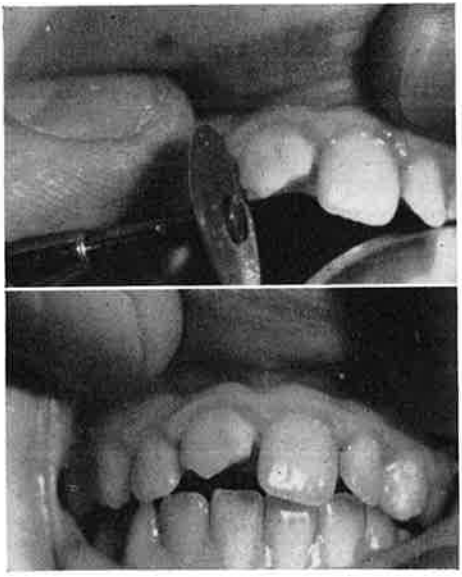


FIG. 26 *(top)*.—Mesial and distal surfaces prepared with diamond disk.

FIG. 27 *(bottom)*.—Centric and incisal positions checked.

colloid heaters and a suitable hydrocolloid inlay syringe. In place of the special hydrocolloid heater a thermos jug with a wide neck may be used. The thermos jug, containing water at a temperature of approximately 160 F., is used for storing and tempering the tube of hydrocolloid and the syringe after the

material in them has been softened by boiling in the sterilizer. The thermos jug equipment has one disadvantage, namely, there is some heat loss through the cork and careful checking of the loaded inlay syringe must be made periodically to see that the hydrocolloid is in a workable condition.

The advantage of using the reversible hydrocolloid revolves around the ability of the material to be liquefied and placed in the mouth at temperatures compatible to the mouth tissues. It flows readily into the fine pin holes and grooves in the preparation and when chilled possesses sufficient elasticity to permit the removal of the impression without distortion. Briefly, six steps are involved in taking an impression of a tooth prepared for a gold-acrylic crown. (1) Liquefy the hydrocolloid in its original tube and in the syringe by boiling in the sterilizer for 10 minutes, or by heating in the special hydrocolloid heater at 208 F. for 10 minutes. (2) Store the preheated material in both the tube and the loaded syringe in the bath, which in the special equipment is thermostatically controlled at approximately 152 F. and in the case of the thermos jug is at approximately 160 F. (3) Select a suitable water-cooled impression tray. Post-dam the tray with counter wax or compound, load it with the tempered impression hydrocolloid and return the loaded tray to the tempering bath, which should be kept at a temperature ranging from 105 to 115 F. (4) Inject the inlay impression hydrocolloid from the syringe (which has been previously loaded and softened and maintained at approximately 152 F.) into the cavity preparation (Fig.

28). This material will be fluid, but heat loss at the needle-point on ejection of the material will cause it to gel; therefore, great care must be exercised to maintain the syringe at its correct temperature. Completely

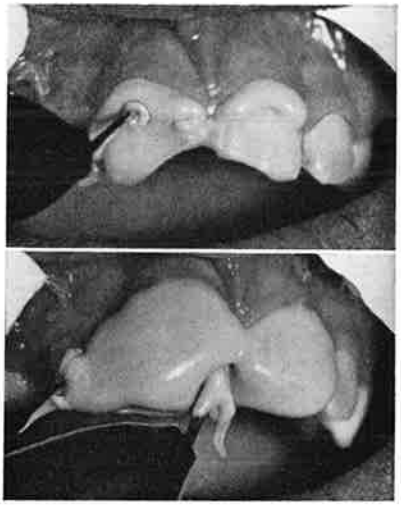


FIG. 28 *(top).*—Adaptation of hydrocolloid impression material around a central incisor prepared for a gold-acrylic crown.
FIG. 29 *(bottom).*—Total envelopment of the prepared central incisor and the adjacent teeth.
(Figs. 28-39 courtesy of Dr. J. B. Pepper.)

envelop the fractured tooth and the adjacent teeth with the hydrocolloid from the syringe (Fig. 29). (5) Place the tray, which has been previously loaded with regular impression hydrocolloid, in the mouth and seat it to place. (6) The hydrocolloid is then brought to a state of gel by the circulation of cold water through the water-cooled tray.

The principle involved in this impression technic is that the impression tray, which contains hydrocolloid at near solidification point, exerts pressure on the hydrocolloid which is injected from the syringe around the prepared tooth. However, in order to obtain a good impression the crown of the tooth in which we are especially interested must be free from any overlap

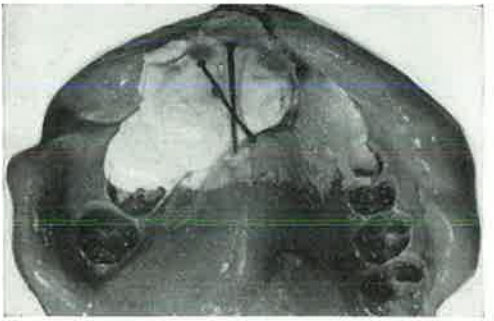


FIG. 30.—Diestone model of fractured tooth seated in impression. Pouring of main cast.

of gingival tissue. Therefore, it is occasionally necessary to provide for tissue retraction. One method used with satisfaction for the retraction of gingival tissue is the treatment crown referred to previously. It is also possible to cauterize the gingival tissue with 8 per cent zinc chloride or by electric cautery. When cautery, mechanical or surgical means are employed, two or three days should be allowed for healing before the impression is taken. Replace the treatment crown in the interval.

Upon removal of the impression, it should be poured

immediately with suitable stone. First, the impression of the tooth for which a gold-acrylic crown is to be made is poured separately and a dowel pin inserted. This section of the impression is allowed to set, is then removed from the impression and is trimmed, lubricated and returned to the impression. The balance of the impression is then poured in stone (Fig. 30), placed in a 2 per cent potassium sulfate solution and allowed

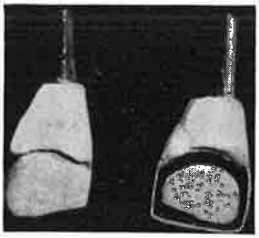


FIG. 31.—Stone die showing dowel pin. Partially waxed open-faced gold crown.

to set. The model is then separated from the impression and allowed to dry out for 24 hours. This method of model-making provides for the removal of the model of the individual tooth, which facilitates waxing the crown (Fig. 31).

Two technics for waxing an open-faced gold crown have been used with success. The first is illustrated with a diestone model and dowel pin. The die is lubricated with Microfilm to facilitate withdrawal of the wax pattern. One thickness of 29 gauge sheet casting wax is adapted over the crown of the die and trimmed so that the labial face is open, except for a

2 mm. wide strap across the gingival margin. Over this single thickness of sheet wax, flow blue casting wax to reinforce the pattern where necessary to meet the needs of strength and contour. A window is left through

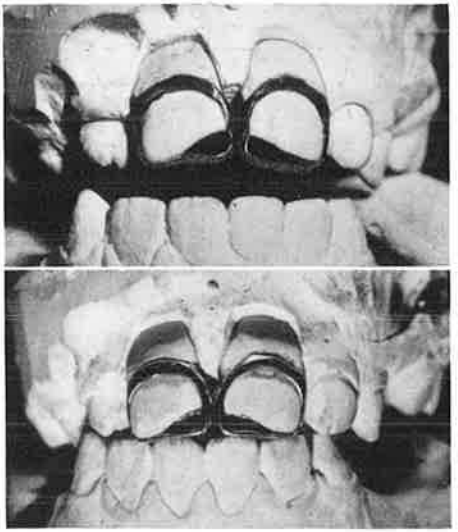


FIG. 32 *(top).*—Open-faced gold crowns waxed. Note window through lingual gold wall.

FIG. 33 *(bottom).*—Open-faced gold crowns in place on model.

the lingual wall of wax in the area corresponding to the lost labial enamel (Fig. 32). This window should be shaped so that it will provide positive retention for the plastic veneer. The translucency of the veneer is enhanced when the gold backing is eliminated.

The casting is made in hard gold to obtain maximum strength. In Figure 33 castings for two central incisors

are shown in place on the models. The window for the plastic veneer is shown clearly in each case.

The second method used in waxing an open-faced gold crown is illustrated in Figures 34–36. In this case an electrolytically deposited copper die has been employed.[9] The following waxing technic is used. A single thickness of 30 gauge pink casting wax is adapted to the entire surface of the crown of the prepared tooth, i.e., on the model (Fig. 34). This is followed by the adaptation of a single thickness of 28 gauge green casting wax to the lingual and both proximal surfaces, but not to the labial (Fig. 35). The mesial and distal extensions of the green wax on the labial surface are trimmed to the general contour of the labial surfaces of the adjacent teeth. The incisal extension of the green wax is trimmed to conform to the incisal edges of the adjacent teeth. The green wax adapted to the lingual surface forms the lingual contour of the casting. Between the green and pink wax layers around the mesial, distal and lingual surfaces, undercuts are developed which provide positive retention for the acrylic veneer. Reinforcement of the pink wax on the labial surface in the gingival region only is the next step. This increases the strength of the labial gingival band (Fig. 36). The final step in the waxing process is to cut out the pink wax covering the labial face. Note that the reinforced labial gingival band is left intact. The contact points must be examined. All surfaces are made smooth ready for the investing. A window should be provided in the lingual wall similar to that described in the first method of waxing.

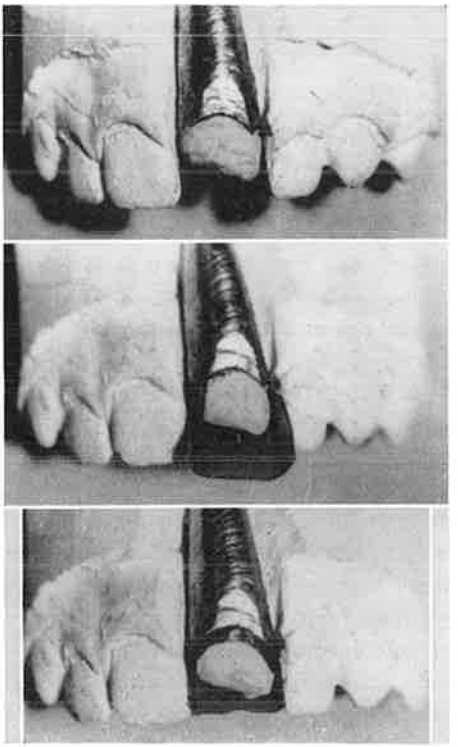


FIG. 34 *(top)*.—Pink wax adapted to the die.
FIG. 35 *(center)*.—Pink and green wax in place.
FIG. 36 *(bottom)*.—Labial gingival band reinforced with green wax. Wax trimmed to contour.

Two objectives must be sought at the time the final fitting of the open-faced gold crown is made: (1) to have an accurately fitting crown which will be tolerated by the gingival tissues and in the functional

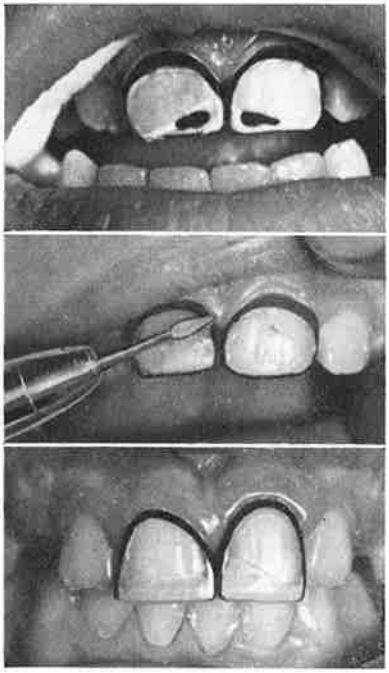


FIG. 37 *(top)*.—Open-faced gold crowns being cemented to place in the mouth.

FIG. 38 *(center)*.—The self-cured plastic veneer being pared down with finishing bur.

FIG. 39 *(bottom)*.—The completed open-faced gold acrylic crown.

biting positions; (2) to have as little gold showing as possible. Where the acrylic veneer is to cover the gold, sufficient bulk of the acrylic is required to maintain a uniform shade throughout the veneer. The finished gold crown is cemented to place and the window made

ready to receive the self-curing resin veneer (Fig. 37). The advantage of the self-curing resin veneer over the laboratory processed veneer is that the cementing medium is eliminated. It is thus possible to obtain more uniformly pleasing esthetic results (Figs. 38 and 39)

A possible danger of the gold-acrylic crown with the labial gingival band is the creation of a food trap on the labial surface between the band and the gingiva. This is more likely when such a restoration is placed on a partially erupted anterior tooth. Subsequently, as the tooth erupts, an area of enamel is exposed in a very vulnerable spot. Sometimes it may be necessary to remake the crown. In a very caries-susceptible mouth, it may even be a wise precaution to remove the crown periodically and check for possible decalcification under the labial band.

The Permanent Restoration

When a final restoration is contemplated, the porcelain jacket crown is likely to be given premier place as the ideal restoration. The age at which the jacket crown preparation can be placed satisfactorily has by common consent been set at 16–18 years.[10] However, the fact is recognized that it is possible to place a permanent porcelain jacket crown restoration at an earlier age if recession of the pulp within the pulp chamber can be shown radiographically to have taken place (see Fig. 20).

As alternatives for the permanent restoration, several types of three-quarter crown restorations, with silicious cement, acrylic or fused porcelain veneers,

may be recommended. Most operators have one which they prefer over all other types.

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CHAPTER 4 CLASS 3

Extensive Fracture of Crown — Involving Considerable Dentin and Exposing the Pulp

Prescription for Treatment

A. Record case history (p. 21)
B. Record results of clinical examination (p. 25)
C. Diagnosis of the case; determine treatment plan
   1. Pulp capping—class 3, division 1
   2. Pulpotomy—class 3, division 2
   3. Pulpectomy—class 4 (Chap. 5)
   4. Extraction of tooth (Chap. 6)

Pulp Capping—Class 3, Division 1

a) Indications for pulp capping
   (1) Small exposure
   (2) Little or no hemorrhage
   (3) Exposure time not over 15–18 hours
   (4) Root apex closed or nearly closed
   (5) Vitality reaction good
   (6) No complications

b) Emergency treatment
   (1) Isolate tooth and exclude moisture
   (2) Wipe clean with sterile water on cotton pellets
   (3) Dry
   (4) Use no strong drugs on dentin or pulp

(5) Cover pulp and dentin with calcium hydroxide
(6) Avoid pressure at all stages of procedure
(7) Cover hardened capping material and exposed enamel with rapid-setting, nonirritating cement
(8) Clean all surfaces of the tooth
(9) Select resin crown form of suitable size and shape; contour the gingival end to fit without impingement on the gingival tissues
(10) Modify crown form with self-curing plastic of suitable shade to create an accurate treatment crown
(11) Check bite registrations and perforate the labial face with a no. 9 round bur to provide for application of pulp tester
(12) Fill crown form with creamy mix of cement and seat to place over tooth
(13) Again check bite in all positions
(14) Advise patient to report at once if pain is experienced
(15) Leave for one week and recall for observation

c) If satisfactory, allow rest period of 6–8 weeks, after which, if tests are satisfactory and radiographic evidence is negative, place a temporary-permanent restoration

d) At a suitable time place more permanent restoration, such as porcelain jacket crown

Pulpotomy—Class 3, Division 2

a) Indications for pulpotomy
(1) Exposed portion of pulp extensive, but not infected or degenerated
(2) Hemorrhage may have taken place
(3) Exposed longer than 18 hours
(4) Root apex wide open
(5) Definite evidence of vitality
(6) No other complications

b) Technic

(1) Anesthetize the pulp by infiltration or conduction anesthesia

(2) Isolate tooth and exclude moisture

(3) All instruments must be sterile

(4) Field of operation must be rendered aseptic

(5) Open pulp chamber with sterile burs and gain good access

(6) Remove bulbous coronal portion of pulp with sharp instruments (not burs)

(7) No strong drugs should be used in pulp chamber

(8) Control hemorrhage with tampons of sterile cotton saturated with very warm sterile water or with camphophenique

(9) Absorb excess moisture with sterile cotton pellet and cover amputated stump with a creamy mix of calcium hydroxide

(10) Avoid pressure but have paste in contact with pulp surface

(11) Seal with cement—may place crown form

(12) Take a radiogram of the tooth for future comparison

c) Allow rest period of 6–8 weeks, then place a temporary-permanent restoration

d) At a suitable time place a more permanent restoration

General Considerations

In this group of fractures one is confronted with the problem of treatment of an exposed pulp. Unfor-

tunately a comparatively large percentage of cases of fracture are to be found in this catagory.

The dental pulp tissue is highly specialized and extremely vascular. It is not at all certain that the normal repair processes for soft tissues apply to injured pulp. Some investigators and teachers have asserted that little or no recuperative powers are possessed by this highly sensitive organ. Perhaps their conclusions have been reached after unsuccessful attempts to apply conservative treatment to pulps exposed by caries in adult teeth. The administration of conservative treatment for exposed pulps must be governed by several factors. In the mature tooth, the pulp is enclosed in a hard, unyielding compartment in which no compensation for an increased blood supply is possible. There is no collateral circulation to take care of the events which accompany inflammation. However, in the cases considered here, the young pulps are unmolested by irritating influences such as caries; one minute they are full of the essence of resistance and the next weakened by exposure to the contaminating influences of oral fluids. From clinical observations, the author is inclined to agree with Davis,[1] who stated: "The possibility of repair in pulp tissue is much in harmony with the repair of the medullary tissue or bone marrow." There is extraordinary recuperative power in the pulp tissue of a young healthy tooth which prior to accidental injury has not been subjected to deleterious irritating influences.

Many cases could be chosen from the records to

illustrate this point, but the radiogram of one case was selected in which the prognosis was most unfavorable (Fig. 40). After the accident in November, 1940, which exposed the pulps in both maxillary central incisors, repeated attempts were made by the family dentist to keep the exposed pulps protected. Every

FIG. 40.—Maxillary central incisors four years after exposed pulps were capped. Prognosis was considered unfavorable at the time of capping.

few days or week or two at best, the pulps were accidentally re-exposed and had to be recapped. Four months after the accident they were given the emergency treatment outlined here, and the radiogram in Figure 40 was made four years later, just prior to preparation of the teeth for porcelain jacket crown restorations. The teeth reacted like normal central incisors during the preparation for the jacket crowns. If ever a prognosis was unfavorable, it was in this

case. The success obtained can be attributed almost entirely to an extraordinary degree of resistance of the pulp tissue.

Kronfeld[2] stressed the fact that the latent power of resistance of the pulp is immeasurable, yet in the same individual, similar injuries to two similar teeth can result in diverse reactions, the one leading to pulp necrosis and the other to secondary dentin formation.

Class 3 cases must be subdivided into three divisions for purposes of treatment. These divisions are based on a classification of the type of exposure. The information collected in the history and through the clinical examination makes it feasible to classify exposures into different types.

A pulp exposed by accident may have a minute pinpoint involvement or a large area, or the bulbous coronal portion of the pulp may be projecting beyond the dentin; it may or may not be bleeding; it may have been exposed for minutes, hours or days; the root of the tooth may be fully developed or still in the process of development; there may be little evidence of vitality on contact with the exposed pulp; there may or may not be other complications, such as displacement and root fracture. The diagnosis and method of treatment can be wisely formulated only when these factors are known and evaluated.

There are four possible treatment plans for the tooth with an exposed pulp. In order of degree of severity of treatment they are: (1) pulp capping; (2) pulpotomy (partial removal of the pulp); (3)

pulpectomy (total removal of the pulp); (4) extraction of the tooth. The discussion in this chapter is confined to the conservative methods of treatment indicated in the first two plans.

The prognosis for the tooth treated under each plan is dependent on the accuracy of the diagnosis made for each individual case. One who resorts to promiscuous capping of exposed pulps is as guilty of failing to recognize the full implications of his actions as is one who errs in the other extreme.

Pulp Capping: Class 3, Division 1

Indications for pulp capping.—These are not difficult to recognize. Therefore it should be within the power of every student and general practitioner to make a quick decision and determine whether the prognosis is favorable or otherwise. The indications for pulp capping might be stated in a general way as follows.

1. The exposed portion of the pulp should be limited to a small area, e.g., one horn of the pulp.
2. Little or no hemorrhage from the pulp should have occurred.
3. The pulp should not have been exposed for more than a few hours (15–18 maximum).
4. The tooth with the almost closed root end is most suitable, yet, all other factors being suitable, the fully developed tooth will respond to capping. The tooth with the undeveloped root end, where the apex is wide open and funnel-shaped, is favorable for capping in some respects, but one must always remember that if the capping treatment is not successful, root canal

therapy is complicated greatly by the open foramen. The results of pulpotomy have been so successful that we prefer to be more radical in management of undeveloped teeth. Our clinical records and observations substantiate this decision.

5. The reaction to the vitality test should be marked. The best method of testing for this sensory reaction is to moisten, not saturate, a pellet of sterile cotton with sterile distilled water and pass it with a light wiping motion over the exposed pulp. Pulps which show little or no reaction are unfavorable for capping.

6. There should be no complications such as root fracture or displacement.

If cases are chosen carefully with a regard for the indications listed, there is reason to expect that the capping procedure will yield satisfactory results, provided also that the actual capping procedure adds no further trauma or irritation to the pulp tissue.

Pulp capping technic.—There are several acceptable technics described in the literature.[3-6] Any procedure found to be satisfactory to the operator is the method of choice. However, irrespective of the method used and the materials employed, certain fundamental biologic principles must be recalled. The odontoblastic layer of the pulp is exposed first, as it is the external layer of the pulp. The odontoblasts are capable of depositing secondary dentin and must be considered important elements in the natural protective mechanism of the tooth. The ultimate objective of pulp capping is to preserve the pulp and odontoblasts so that secondary dentin will eventually be deposited

and form a solid calcified barrier or seal over the opening which led to the pulp exposure. These odontoblasts should be preserved in a healthy condition if at all possible. The odontoblasts are highly specialized cells, and it is questionable whether they are regenerated, once they are damaged. In the course of covering them, nothing should be done to irritate or injure them. Strong drugs and pressure are chief among possible irritants.

Considerable research work has been done on the reaction of the pulp tissue to various inert capping materials. Zander,[7] and Eastlick, Wilber and Crowley[4] have reported excellent results with calcium hydroxide and distilled water. Dillon[6] uses a paste of calcium carbonate 10 parts and calcium phosphate 1 part, moistened with a saturated solution of calcium hydroxide in distilled water, in which a trace of calcium fluoride and magnesium phosphate is added. The exact quantity of the last two ingredients he does not state. The saturated solution of calcium hydroxide is called a "stock solution"; it is advisable to make it fresh periodically.

Many suggestions have been made regarding avoidance of pressure on the exposure during manipulation. These include careful placement over the exposure of any of the following: a piece of cellophane, blotting paper, a heavy pad of writing paper or a copper, aluminum, platinum or gold cap.

A method of pulp capping found to be satisfactory is described here. Figure 41 shows a typical pulp exposure resulting from trauma. The mesial horn of

the pulp is exposed. The history of the case is related because it is typical. A boy, 10½, fractured the maxillary left central incisor when jumping from a gymnasium horse at 5:00 P.M. He reported for treatment at 9:00 A.M. the next day. Little or no bleeding was evident. The pulp was extremely sensitive to touch,

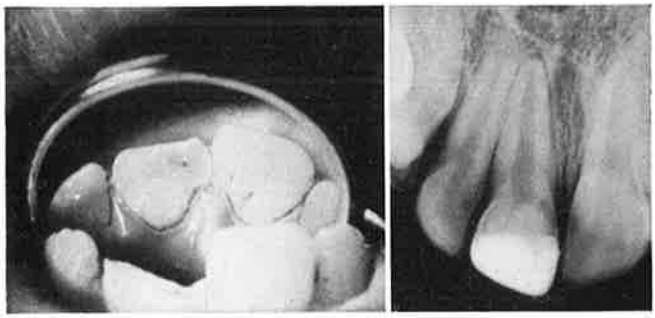

FIG. 41 *(left).*—Mesial horn of the pulp exposed.
FIG. 42 *(right).*—Radiogram of same case.

using the method of testing suggested earlier (p. 81). The root apex was expected to be closed at this age and this was shown to be true by means of a radiogram (Fig. 42). Furthermore, there were no complications, such as root fracture or displacement. The decision was reached quickly that the prognosis in this case was favorable and the pulp was capped.

The tooth should be isolated, using the rubber dam wherever possible. This is sometimes complicated because of trauma to the soft tissues and loss of tooth structure. Satisfactory isolation of the tooth can be obtained by use of cotton rolls and the saliva ejector.

The tooth is washed clean with pellets of cotton and tepid sterile normal saline solution. No strong irritating drugs are placed on the tooth. Drying is done carefully, but without overdehydration. A mixture of the capping material is prepared and applied to cover the pulp. In the case shown in Figure 43, a paste of

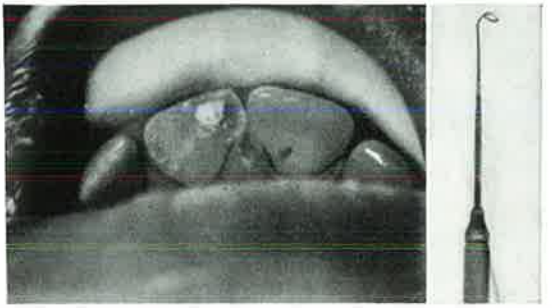

FIG. 43 *(left)*.—Capping paste in position over the pulp.
FIG. 44 *(right)*.—Loop used to place capping paste.

calcium hydroxide was carefully traced around the pinpoint exposure until a small compound was built around it, and then some of the thin capping paste was traced in over the exposure itself, like a roof. The capping paste is mixed and traced into position with a loop about 1 mm. in diameter formed by shaping a flexible smooth root canal pathfinder (Fig. 44).

After the pulp exposure is carefully covered, the remaining exposed dentin is covered too with the capping paste.

The next step in the procedure is to cover the enamel exposed in the fracture and the capping mate-

rial over the dentin with a thinly mixed, rapid-setting nonirritating cement. The completion of this step is seen in Figure 45. The cement covering must be placed over the tooth while of *thin consistency,* in accordance with the principle of avoiding pressure at every stage in the procedure. Furthermore, it is placed over the

FIG. 45.—Cement capping over the capping paste and enamel area involved in the fracture.

initial protective capping to form a hard rigid casing, so that no pressure can be transmitted to the pulp in any subsequent procedure. The young patient is then given a brief respite before the tooth is given careful prophylaxis.

A treatment crown is then prepared and placed over the tooth (Fig. 46). The technic is that given on pages 48 f.

Before the patient is dismissed, both the parent and the patient should be impressed with the fact that any signs of pain, soreness or abnormality within the tooth just protected should be reported to the dentist at once.

The patient is dismissed for a week and then seen for observation only. If results are satisfactory after a week, a six to eight week rest period is allowed, as in the class 2 cases. For a temporary-permanent restoration after this interval, the same methods are used as outlined in Chapter 3. During construction of a restoration, great care must be taken to avoid

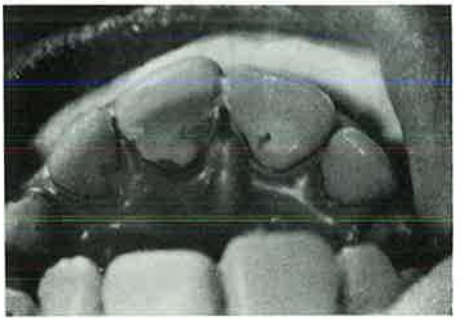

FIG. 46.—The resin form cemented to place over the capped pulp.

re-exposure of the pulp. Figure 47 shows the radiogram at the time of pulp capping two maxillary central incisors and Figures 48 and 49 the same teeth four years later. The prognosis in this case was favorable at the outset, and it is not surprising that the pulps still respond to vitality tests and in every other way seem normal.

A similar case is seen in Figures 50–52, with a satisfactory four year history since the accident and the capping of the pulps of the two maxillary central incisors.

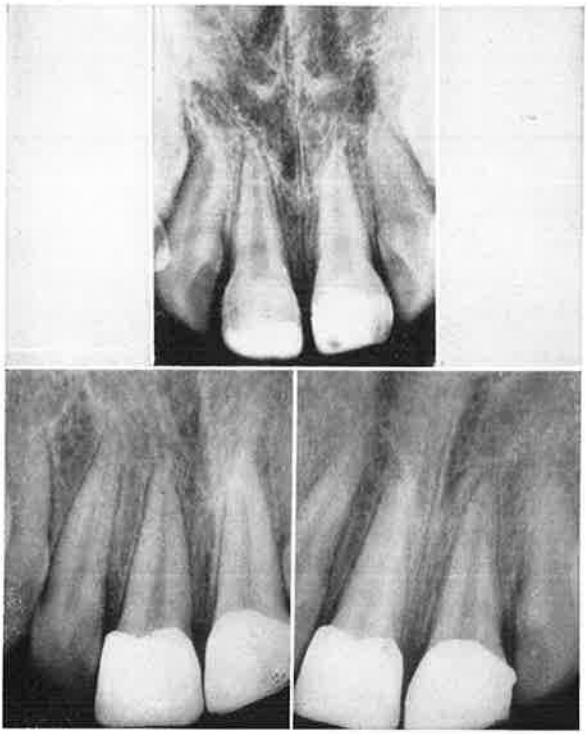

FIG. 47 *(top)*.—Maxillary central incisors immediately after pulp capping.
FIGS. 48 AND 49 *(bottom)*.—Same case, four years later, showing normal periodontal and apical tissues.

The ultimate objective in these cases, as in the class 2 series, is the maintenance of a normal healthy pulp and the continuance of the regular developmental processes at the root apex and within the pulp cham-

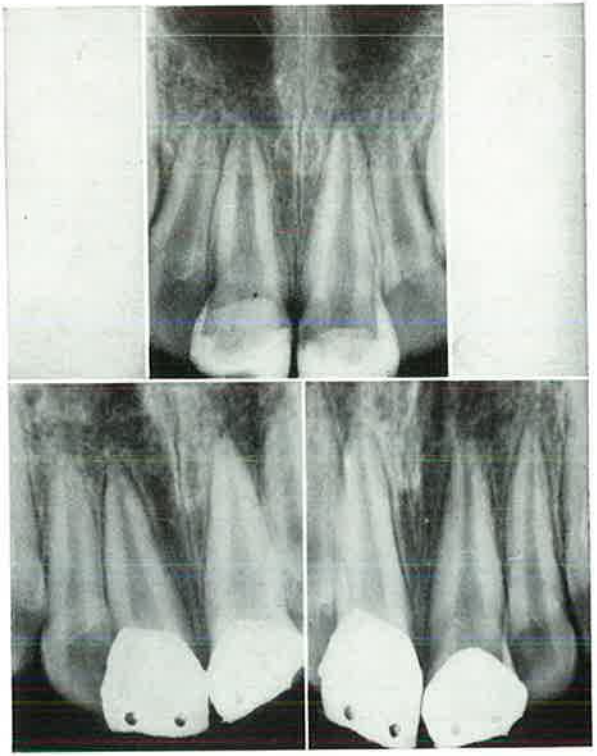

FIG. 50 *(top)*.—Maxillary central incisors immediately after pulp capping.

FIGS. 51 AND 52 *(bottom)*.—Same case, four years later.

ber and root canal. Realization of this objective is evident in the case shown in Figures 50–52. Both the root apexes and the pulp chambers show marked change in the four year interval. If this progress continues, restoration of the lost tooth structure with a

porcelain jacket crown will be relatively safe in the near future.

"Pulp capping failures will range anywhere from thirty to fifty per cent," according to Sweet.[8] He believes such a high percentage of failures with pulp capping in these cases generally justifies the choice of a vital pulpotomy.

Pulpotomy: Class 3, Division 2

The *indications* for partial removal of the pulp, or pulpotomy, may be clearly defined. Two conditions affect the outcome in pulps exposed so extensively that pulp capping is not indicated; pulpotomy is indicated when the pulp is still entirely vital, and when the root apex is wide open, precluding root canal therapy.

The following list may clarify the indications for pulpotomy. (1) There is extensive exposure of the pulp, even to include the whole bulbous coronal portion, projecting beyond the end of the hard tooth structure in a pedunculated form. (2) Hemorrhage has probably taken place. (3) The pulp may have been exposed for 48–72 hours. (4) The root end of the tooth is still in the process of development; all instances of even minute exposure, which might otherwise be suitable for capping, are better treated by pulpotomy if the root apex is wide open. (5) There should be no complications such as root fractures or displacement. (6) There should be evidence of vitality reaction or red blood in the exposed pulp; a degen-

erating or necrotic pulp will give neither of these signs.

Successful treatment of the more serious cases of pulp exposure by the pulpotomy technic depends on the assumption that on exposure of the pulp "the inflammatory reaction is for some time confined to the coronal portion of the pulp, and that the pulp tissue in the canal shows no evidence of hyperaemia or inflammation."[9] In most teeth in which the pulp is exposed by fracture, the pulp immediately before exposure was healthy and undisturbed. Therefore, after a short period of direct exposure to oral fluids, it seems reasonable to assume that with careful and aseptic removal of the coronal portion of the pulp, the prognosis for survival of the radicular portion of the pulp will be favorable. Following successful removal of the coronal portion of the pulp, the maintenance of a normal state in the root canal portion is partly dependent on the ability to place a nonirritating, antiseptic, inert material against the pulp stump. The technic, while somewhat exacting, is within the scope of the general practitioner. Many pulps can be maintained in a state of health and normal development of root structure can proceed unchecked if action is taken quickly.

Pulpotomy technic.—Various technics have been advanced by different authors in the past 10–15 years and a considerable amount of time has been devoted to research on this subject. Most of the conclusions arrived at after careful study indicate that this method of treatment is rational for young permanent teeth, whether exposed by caries or by trauma. A satisfactory

technic, used for a number of years, is adapted from that used in the Guggenheim Clinic, New York City.

Careful selection of the case is of first importance. A good radiogram should be in view at the time of the operation. The operating tray and every instrument and dressing used should be sterile. The dentist and his assistant must practice the most rigorous aseptic measures in preparation for the operation. When everything is in readiness, anesthesia is obtained with infiltration or conduction methods.

The tooth, and possibly a few adjacent teeth, are included in the rubber dam. The field of operation which includes teeth and rubber dam is carefully cleaned and rendered aseptic with a 3 per cent iodine bath followed by a similar wash of 70 per cent alcohol. The field is dried and is now ready for the operation.

The instruments required for the operation are few and simple.

The following instruments have been used in the preliminary procedures.

Cotton pliers
Explorer
Mouth mirror
3 or 4 dappen glasses
Cotton pellets
Cotton rolls
Saliva ejector
Rubber dam equipment
Anesthetic equipment

In the actual operation of removing the coronal portion, the following instruments should be ready.

Two each of no. 5 and no. 9 round burs for straight hand piece
Two no. 702 fissure burs for straight hand piece
One sharp discoid (Fig. 53)
One sterile straight hand piece
A plastic instrument
Cement slab and spatula

The pulp chamber is opened with a no. 9 round bur and access gained to the full extent of the pulp chamber with a no. 702 fissure bur. Two of each size of bur is suggested in case one is accidentally dropped or becomes clogged. The burs should be placed in the hand piece without touching them with the hands.

The pulp is removed carefully with the sharp discoid by placing it into the opened pulp chamber and up to the point at which the pulp is to be severed. A cutting action is used, severing the pulp against the hard dentin walls and scraping down the walls to the orifice. Repetition of this procedure several times severs the pulp with a clean break rather than by tearing it to pieces with a large round bur. Nevertheless many operators use the large round bur with success. The point at which the pulp should be amputated is illustrated well in Figures 54 and 55. At a point 1–2 mm. rootwise to the cemento-enamel junction line, a constriction of the pulp chamber is seen in both the mesiodistal and buccolingual sections of the maxillary central tooth. This is the ideal level for amputation of the pulp.

20
2
12

18

FIG. 53.—Discoid excavator.

Strong drugs should not be used to control the bleeding at this point or at any subsequent stage. If a drug is necessary to control the bleeding, and that is seldom the case, camphophenique is used. Any debris on the walls of the pulp chamber can be removed with the discoid or washed out with a cotton

pellet moistened with sterile distilled water or camphophenique.

A creamy paste of calcium hydroxide, prepared by mixing powdered calcium hydroxide with a drop of sterile water or anesthetic solution, is gently teased over the pulp stump with a loop instrument (Fig. 44). Here again, the greatest care must be taken to avoid pressure on the pulp stump. The thin mix is readily

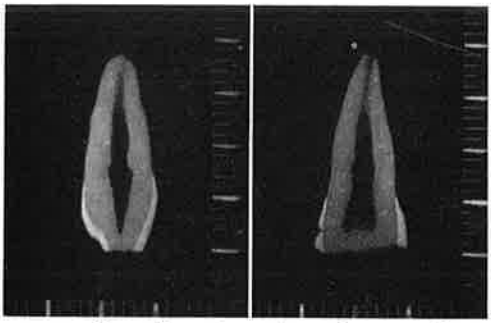

FIG. 54 *(left).*—Buccolingual section of a maxillary central incisor, showing constriction at the junction of the pulp chamber and root canal.

FIG. 55 *(right).*—Same tooth, mesiodistal section. The millimeter scale permits exact measurements.

displaced under pressure which is an important feature of the capping procedure. Nevertheless care should be taken to insure contact of the capping material with the pulp stump and elimination of air spaces adjacent to the pulp.

Over the capping paste, a thin creamy mix of cement is placed in a similar manner and the pulp chamber is closed with cement. A radiogram is taken

FIG. 56 *(left).*—Maxillary left central incisor immediately after pulpotomy. Note undeveloped root apex and size of root canal. FIG. 57 *(right).*—Same case, three years later. Note complete development of the root and formation of a dentin bridge at junction of crown and root where the pulp was severed.

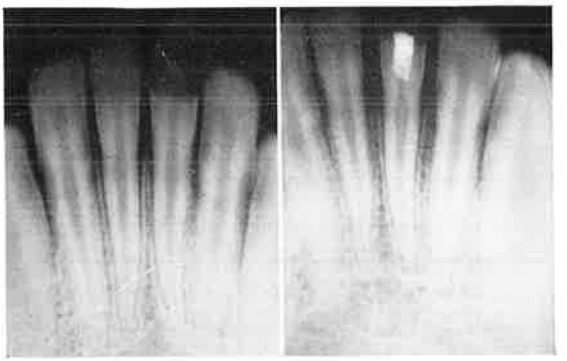

FIG. 58 *(left).* — Mandibular right central incisor before pulpotomy.
FIG. 59 *(right).*—Same case, 15 months later.

at this stage for verification of the filling of the pulp chamber and for comparison with later radiograms. A rest period of six to eight weeks is then allowed before proceeding to place a restoration.

Figure 56 shows a radiogram made after pulpotomy; Figure 57 shows the same case three years later. There is definite evidence of normal continuation of development of the tooth root and of the formation of a heavy bridge of dentin at the level of the pulp stump. There is also evidence of more rapid closure of the root canal space than in the adjacent central incisor.

Figures 58 and 59 also illustrate the formation of a dentin bridge after pulpotomy. There is some evidence also of a calcific deposit appearing in the root canal beyond the dentin bridge.

The dentin bridge formation referred to in these cases has been studied microscopically by Zander and Law.[5] Figure 60 shows a high power magnification of the dentin bridge and adjacent pulp tissue. The capping material used in this case was calcium hydroxide and distilled water. Among other capping pastes used satisfactorily is one made from the following powder and liquid.

Powder (U. G. Rickert's formula)	
Finely divided silver	24.74%
Zinc oxide	34.00%
Thymol iodide	10.55%
Oleoresins	30.71%
Liquid	
Glycerin	1 oz.
Iodine crystals	8 gr.

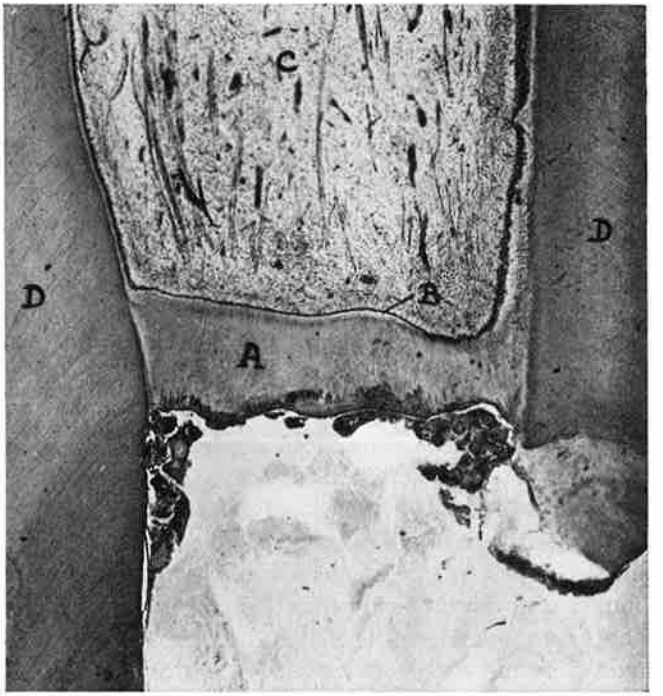

FIG. 60.—Dentin bridge formed over pulp stump after pulpotomy. *A*, dentin bridge; *B*, odontoblasts; *C*, pulp; *D*, root dentin. (Courtesy of Dr. H. A. Zander and Dr. D. B. Law.)

There seems to be general unanimity of opinion that zinc oxide and eugenol alone have not been as satisfactory as other materials suggested.[10] Several investigators refer to the incorporation of a small percentage of paraformaldehyde in the capping paste as promoting calcification within the root canals. The radiograms shown in Figures 57 and 59 would substantiate this view.

Restoration for the Tooth

The tooth subjected to the pulpotomy operation should be given a rest period of six to eight weeks before a restoration is placed. This period may be extended if it is considered advisable, but any prolongation of the time between the accident and the restoration of the tooth means increased discrepancy in the space to be restored. Consideration of the type of restoration to be recommended leads to a review of the suggestions made in the discussion of the temporary-permanent restoration (pp. 57 ff.). Perhaps the danger of adding irritation to the pulp in these cases is reduced in proportion to the extent of the artificial recession of the pulp created by the very nature of the treatment it has already received.

The extensive loss of crown structure which is common to such a case renders retention of a restoration more difficult, so that a modification of the gold-acrylic crown is required. Use of the gold-acrylic crown with accessory pin anchorage is therefore indicated. The gold portion of the crown must be cast. The preparation for the crown involves parallel proximal walls,

reduction of the labial enamel to eliminate undercuts and reduction of the lingual enamel to clear the bite positions. Three accessory pins of 20 gauge are recommended for anchorage. If the holes are cut with a no. 3 round bur, 20 gauge wire pins fit comparatively accurately. The open-faced gold casting can be made by the direct method but is done preferably by the indirect method on an investment die in which the pins are embedded. Waxing of the labial veneer and processing of the acrylic have been discussed in Chapter 3.

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CHAPTER 5 CLASS 4

The Traumatized Tooth Which Becomes Nonvital—with or without Loss of Crown Structure

Prescription for Treatment

A. Record case history (p. 25)
B. Record results of clinical examination (p. 25)
C. Diagnosis of the case; determine treatment plan
   1. Vital tooth—class 4, division 1
   2. Nonvital tooth—pulp chamber opened by fracture—class 4, division 2
   3. Nonvital tooth—pulp chamber not opened by fracture—class 4, division 3

Vital Tooth—Class 4, Division 1

a) Indications for devitalization
   (1) The tooth must be useful
   (2) Unable to cap or perform pulpotomy
   (3) Root development complete or nearly complete
   (4) Young healthy patient
   (5) No complications such as a fractured root

b) Treatment
   (1) Anesthetize pulp with local anesthesia
   (2) Isolate tooth with rubber dam

(3) Sterilize field of operation
(4) Use only sterile instruments and dressings, etc.
(5) Gain ample access to pulp chamber
(6) Using original radiogram as a guide, place stop device or marker on a smooth pathfinder and explore canal; constriction at dentocemental junction can be sensed
(7) Remove pulp with barbed broach
(8) Ream canal to enlarge and clean thoroughly
(9) Make radiogram with measuring device in canal
(10) Control bleeding with blunt sterile absorbent points
(11) Place medicated dressing of oil of cloves on a blunt sterile absorbent point
(12) Seal in canal for two to three days
(13) At second appointment open canal under rigidly aseptic conditions
(14) Take material for culture test
(15) If culture is negative, fill canal at third appointment
(16) If canal culture is positive, use stronger antiseptic dressing until it is negative, as in the case for treatment of a necrotic pulp (see division 2)

c) Consider the final restoration

Nonvital Tooth, Pulp Chamber Opened by Fracture—Class 4, Division 2

a) Indications for treatment
(1) Tooth must be useful
(2) Young healthy patient
(3) Periodontal tissues intact over two thirds of root length
(4) Satisfactory restoration can be placed
(5) No discharging sinus present (chronic)
(6) Root development favorable

b) Treatment

(1) Isolate tooth with rubber dam
(2) Sterilize field of operation
(3) Use only sterile instruments and dressings, etc.
(4) Gain ample access to pulp chamber
(5) Clean out only superficial debris (do not enter root canal)
(6) Place a nonirritating germicidal drug, e.g., camphorated paramonochlorophenol, on a pledget of sterile cotton, in pulp chamber
(7) Seal with cement
(8) At second appointment, 48 hours later, use rubber dam, sterile field, and instruments
(9) Remove dressing from pulp chamber, flood with chlorinated soda; take radiogram with file or reamer in place with marker set at incisal edge to prove length of tooth, record this length and place marker at similar length on all instruments entering canal; with reamers and files, work through chlorinated soda to enlarge root canal (upper anterior canals to no. 6, lower anterior canals to no. 4 file diameter); irrigate thoroughly with chlorinated soda and hydrogen peroxide used alternately
(10) Saturate a dull paper point with camphorated paramonochlorophenol and place in dried canal (an alternative is the polyantibiotic treatment suggested by Grossman[1])
(11) Seal with cement
(12) Inoculate culture mediums at third appointment; replace same medicament used at second appointment and double seal
(13) Subsequent appointments 48–72 hours apart until two consecutive cultures are negative
(14) The principle of rotation of drugs may be used if antibiotic drugs are not employed

(15) Fill canal when two consecutive negative cultures are obtained
(16) When apical area is present, root resection or root apex curettement may be indicated

c) Consider the final restoration

Nonvital Tooth, Pulp Chamber Not Opened by Fracture—Class 4, Division 3

a) Indications for treatment
(1) Tooth must be useful
(2) Young healthy patient
(3) Periodontal tissues intact over two thirds of root length
(4) No discharging chronic sinus
(5) Root development favorable

b) Treatment
(1) Isolate tooth with rubber dam
(2) Sterilize field of operation
(3) Use only sterile instruments and dressings, etc.
(4) Gain ample and convenient access to pulp chamber
(5) Clean out only superficial debris (do not enter root canal)
(6) Place a nonirritating germicidal drug, e.g., camphorated paramonochlorophenol, on a pledget of sterile cotton, in the pulp chamber
(7) Seal with cement
(8) Warn patient to report if discomfort occurs
(9) At second appointment, in 48 hours, use rubber dam, sterilize field and instruments, etc.
(10) Remove dressing, enlarge canal to adequate diameter and estimated length; irrigate thoroughly; prove length of tooth by x-ray
(11) Place blunt paper point in root canal and saturate with mild nonirritating drug, e.g., camphorated paramonochlorophenol (in poly-

antibiotic treatment, fill canal with suspension, place a short, blunt paper point in canal and double seal with gutta-percha and cement)

(12) Seal with cement

(13) At third appointment, 48–72 hours later, use rubber dam, etc., remove dressing, dry canal with sterile paper point, take culture material and incubate; replace same drug in root canal under double seal of gutta-percha and cement

(14) Subsequent appointments 48–72 hours apart until two consecutive cultures are negative

(15) Medicaments may be alternated in keeping with principle of drug rotation unless antibiotic suspension is used

(16) Fill canal when two consecutive negative cultures are obtained

c) Postoperative treatment

(1) When apical area is present, watch and wait for six to nine months

(2) If no change, perform periapical curettage

(3) Because no restoration is required for intact crown, bleaching may be necessary to improve esthetics

(4) If bleaching is not satisfactory, perhaps advise artificial crown to restore esthetics

General Considerations

In the classification advocated as a basis for treatment, class 4 includes all cases in which traumatized teeth become nonvital, whether by intention or by force of circumstances. Treatment of these nonvital teeth involves the consideration of many problems. No elaborate explanation need be sought for justifying the introduction of root canal therapy into the program designed to give the best dental service that

can be rendered for these cases of accidental injury. If root canal therapy is indicated at all in the practice of dentistry, and we take a strong stand on the affirmative side of this question, then in the young healthy patient the prognosis is good. A tooth retained as the result of successful root canal therapy makes an infinitely better space-maintainer than any artificial substitute that can be devised for the young patient. In some cases in which root canal therapy is carried out, the predominating motive is to gain time. On the other hand, considerable permanency may be achieved for many of these teeth treated successfully.

Objectives of root canal therapy.—A fine expression of the objectives of root canal therapy has been given by Coolidge.[2] He writes: "The purpose of pulp treatment and root canal filling is to prolong the usefulness of a tooth so that it may function in mastication after the loss of the pulp, without harm to the host."

A summary of the steps leading up to this state is outlined here. (1) Remove the entire contents of the pulp chamber and root canal under strictly aseptic conditions. (2) Establish and maintain a condition of asepsis within the root canal, no matter what the initial status of the tooth. (3) Fill the enlarged, aseptic canal completely.

If these requirements are adequately fulfilled, the success of the operation will be revealed by the following evidence in subsequent radiograms. (1) There will be a periodontal membrane space of uniform thickness and unbroken continuity around the apex of the root. (2) An unbroken lamina dura line of the alveolus

will be seen beyond the periodontal membrane space. (3) The apical root structure will have density equal to that of any portion of the root, i.e., no evidence of absorption. (4) The density of the alveolar bone surrounding the apical region of the root-filled tooth will compare favorably with that of bone surrounding adjacent vital teeth.

In the discussion of the possible plans of treatment for the tooth with the accidentally exposed vital pulp, pulpectomy was advised when the more conservative procedures of pulp capping and pulpotomy were contraindicated. In these cases the root apex is not likely to be infected, and even the radicular portion of the pulp may be free from infection. Aseptic removal of that pulp precludes the probability of infection engulfing the apical alveolar regions which, if sealed off with a good root canal filling, should remain healthy indefinitely, provided the patient's general systemic resistance remains good. At the other extreme is the tooth with infection beyond the apex, even in the young healthy patient. Between these extremes are many intermediate stages, each with its own peculiar problems. Discretion in making a diagnosis followed by systematic methods of procedure is essential for success. Let us consider the application of root canal therapy to the class 4 cases of traumatized anterior teeth.

The Vital Tooth: Class 4, Division 1

Indications for devitalization.—(1) Because of circumstances beyond our control, it is sometimes impossible to cap successfully or perform a pulpotomy on

the vital pulp exposed accidentally by trauma. Root canal therapy is indicated in these cases provided certain other factors are satisfactory. (2) The root should be completely or nearly completely developed. Radiographic study is important in the determination of this factor. (3) The prognosis for success is enhanced if the patient is young and in good health. (4) There should be no other complications, such as a fractured root or displaced tooth. (5) The tooth must be of value to the patient both as a functioning unit in the developing arch and esthetically.

Principles of treatment for root canal therapy.—The outline of procedure in root canal therapy is not so exacting that it is beyond the ability of the average student and practitioner. A few basic principles must be followed. Fundamentally, they are the cardinal principles of asepsis required for modern surgery. When the root canal of the tooth is entered, direct access is opened to the deep apical periodontal tissues and surrounding bone. Under no circumstances would a surgeon enter the deep bony structures of the body without first making the most intensive effort to establish asepsis, and one is obliged to do the same when entering the root canal of a tooth.

Three aspects of asepsis must be considered, namely, the field of operation, the instruments and dressings used and the establishment and maintenance of asepsis within the root canal. The field of operation—the tooth in question—must be isolated from the contaminating influences of the saliva and then cleansed and treated to eliminate any adherent surface infection. The only

really effective means of isolating the tooth is by means of the rubber dam. Any substitute for the rubber dam, such as cotton rolls held in place by a rubber dam clamp or automaton, aided by the saliva ejector, is not strictly satisfactory. When a tooth is broken down so extensively that it is impossible to place the rubber dam and maintain a seal around the gingival region, a copper or gold band should be adapted and cemented in place on the tooth for the duration of treatment. There are many disinfectants which satisfactorily eliminate surface contamination on the isolated field. Grossman[3] suggests the use of untinted tincture of Metaphen, and many other medicaments have been advocated.

The instruments and dressing materials to be used during the operation must be sterile. Large instruments may be sterilized in boiling water, hot oil or autoclaving or by the dry heat oven sterilizer. It is inadvisable to boil or autoclave the fine instruments which actually enter the root canal, since initiation of rust may bring tragic fracture of the instrument within the root canal. Files, reamers or broaches should not be flamed for crystallization of the steel may weaken the instrument. These instruments may be sterilized in dry heat at 300 F. Grossman[3] advocates the use of the molten metal sterilizer at the chairside during the operation. This type of sterilization depends on the immersion of the instrument point or dressing material into low-fusing molten metal contained in a suitable small receptacle. The temperature of the metal (lead solder) is approximately 340 F. Instruments require about 5 seconds' im-

mersion and absorbent points and cotton pellets may require 10 seconds. During treatment, instruments not actually used within the root canal may be resterilized by dipping them in alcohol and flaming them carefully two or three times. Grossman[3] describes a simple home-made metal sterilizer.

Asepsis within the root canal is accomplished during the course of treatment by antiseptic and germicidal medication. It is important to remind the operator at this stage, however, that when there is infection within the root canal, great care must be exercised during instrumentation within that canal to avoid the risk of extending the infection beyond the apex.

Technic for the class 4, division 1 case.—The case requiring removal of the vital pulp from the extensively fractured anterior tooth and subsequent filling of the root canal is probably the simplest type to control in this group. Profound anesthesia may be obtained with either infiltration or conduction methods. In extremely nervous individuals, premedication with 1–1½ gr. of pentobarbital sodium (Nembutal) is recommended. It is difficult to work on young patients who are under great tension; furthermore, the effectiveness of the local anesthetic seems delayed in such patients. The relaxation which follows premedication is helpful. Immediately after the injection is completed, the tooth and the adjacent teeth are isolated. If the rubber dam cannot be adapted satisfactorily because of loss of crown structure, a suitable band is cemented to place. The field of opera-

tion is rendered aseptic with untinted tincture of Metaphen or Zephiran chloride or one of the various other medicaments recommended for this purpose.

The instrument tray should be prepared aseptically by the assistant, who has conscientiously maintained absolute cleanliness during the proceedings. The operating tray should be covered with a folded, autoclaved towel which overlaps its edges. Within its folds should be placed the following instruments and equipment.

Three sterilized dappen glasses
Mouth mirror
Cotton pliers
Explorer
Spoon excavators, middle size
Plastic instrument
Scissors
Prepared burs — round no. 5 and no. 9 (two of each—straight hand piece), fissure no. 702
Prepared pathfinders, two each of various sizes
Prepared barbed broaches, two each of various sizes
Prepared reamers and files, two each of various sizes
Stop measuring device
Cotton waste receptacle
Cotton pellets and absorbent points

If cotton waste is placed immediately in the receptacle provided and the used instruments are systematically placed on separate layers of the folded, sterile towel, the instruments which remain can be maintained in their original state of asepsis until they are required. These details should not prove overwhelming if the operator is systematic. Nearby, the molten metal sterilizer and the medicaments are ready. These should not be placed on the operating tray because of danger of accident and also because their receptacles cannot be sterilized.

In the straight hand piece previously sterilized by boiling, autoclaving or chemical means, is seated a

small round diamond point, using the sterile cotton pliers and not the fingers. Change to a bibevel drill when the dentin is entered, and enter the pulp chamber by directing the drill at right angles to the long axis of the tooth. Again change to a flame bur, made from a fissure bur twirled on a lathe stone to remove the shoulder, and with a rotating motion funnel the entrance to the root canal. The pulp is then removed from the pulp chamber and root canal. A barbed broach of suitable size (the large root canals of central incisors will admit a large barbed broach) is passed down the canal to the apical region, given a half to full turn and withdrawn. The entire pulp will probably be removed at this one stroke. If the pulp tissue has undergone some disintegration, it will be more difficult to remove the entire contents of the root canal intact. Several insertions of the broach will be required, and owing to the laceration caused in these cases and the initial state of congestion in the pulp, excessive bleeding may be encountered at this stage. Not until all the remnants of the pulp tissue are removed can the hemorrhage be controlled. Take a culture test by placing a sterile paper point in the root canal, withdrawing and dropping it into a tube of medium. The root canal is enlarged and made uniform in size with spiral reamers and files at this juncture. Even if the canal is very large, the walls should be filed to remove adherent odontoblastic filaments and irregularities of the canal wall.

Preparation for measurement of the size and length of the root canal follows. A reamer or file which fits

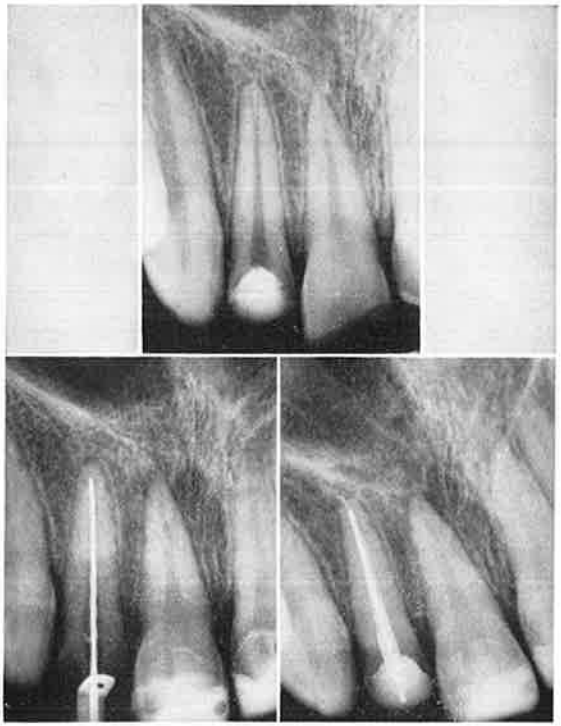

FIG. 61 *(top).*—Maxillary left lateral incisor with extreme pulp exposure.

FIG. 62 *(bottom left).*—Same case. Diagnostic measuring reamer in place.

FIG. 63 *(bottom right).*—Same case. Canal completely filled.

the canal snugly at the apex, as determined by the degree of frictional retention of the instrument in the canal, is fitted with a stop measuring device. The adjustment of this device is calculated from an estimated length of the canal observed in the initial radiogram. Knowledge of the average length of various teeth is useful too in establishing the position of the measuring device on the reamer or file. With the diagnostic instrument in place, a radiogram of the tooth is made and the exact length of the canal established (Fig. 62). The size of the instrument which fits snugly at the apex is the size of the first filling point to be used to fill the canal. Additional filling points may be used to obliterate the root canal by lateral condensation. The length is known accurately. With this complete information about the canal, the actual operation of filling the root canal to the apex appears to be scientifically accurate (Fig. 63). There is no need for guesswork if care is taken in the various steps.

Hemorrhage is seldom difficult to control. Copious irrigation with warm sterile water usually halts the flow of blood. An all-glass syringe is used, and the returning water is caught on sterile cotton held at the incisal edge of the tooth. If hemorrhage persists, it is a sign that a portion of the pulp remains within the root canal. The canal is dried with sterile paper points. These are changed repeatedly until the last one is comparatively dry. A medicated absorbent point is sealed in the canal until the next appointment. The medicament used in division 1 cases should be antiseptic, nonirritating and hygroscopic. Among the many of this type to be recom-

mended, eugenol and camphophenique are satisfactory. It is expected that the patient will experience little or no discomfort between this appointment and the next, 48 hours later. Sometimes slight inflammation develops at the apex following severance of the pulp tissues; hence, it is not advisable to fill the canal at the same sitting that the pulp is removed. Supporting this contention is the probability that a few pulp shreds may be left behind, and these would be traumatized with the pressure of the canal filling material, causing inflammation. Slight bleeding or oozing may follow the loss of vasoconstriction of the apical tissues when the local anesthetic effect disappears from the region. For all these reasons, or any one alone, the practice of filling the canal immediately after the pulp removal is not recommended.

At the second appointment, 48–72 hours later, the canal is opened under rigidly aseptic conditions. If the original culture test proves negative and there is no evidence of pericementitis, the root canal may be obliterated at this appointment.

The procedure preferred by the author at the second appointment is to inoculate a sterile absorbent point with the contents of the canal and place this point in a broth medium for 48 hours in the incubator. An antiseptic dressing (eugenol or camphophenique) is sealed in the canal for another interval of 48 hours. A negative culture at that time is accepted as the signal to proceed. When canals are putrescent at the outset, two consecutive negative cultures are required.

The actual operation of filling the canal is not difficult if all the intermediate stages have been adhered to faithfully. The length and size of the canal at the apex are known quantities. A series of root canal filling points is chosen to meet the requirements of size and length. The points may be gutta-percha or silver. Strict asepsis must be maintained at every move. The cementing substance with which the canal walls are sealed or lined must be plastic, nonirritating, moisture-proof, insoluble, nonshrinking, nonconducting, must not discolor and must be opaque to x-rays. Many suitable mixtures have been suggested and each has its salient features. The one suggested by Rickert and Dixon[4] is highly satisfactory. The proportions have been varied slightly from the original formula.

POWDER

Zinc oxide, C.P.	3 parts
Precipitated silver (200 mesh)	2 parts
Resin (W.W.)	1 part
Thymol iodide	½ part

LIQUID

Oil of cloves	80 cc.
Canada balsam	20 cc.

The canal is dried with alcohol. The cementing mixture is prepared on a glass slab with a steel spatula, both of which have been sterilized. The cementing substance should have the consistency of a creamy cement and should "string out" when the spatula is withdrawn from the mass. The cement is carried into the canal on a sterile reamer, and with a reverse or pumping action the walls are coated and an attempt

is made to carry the cement into the apical third of the canal.

A selected point is picked up with the college pliers and passed through the cement on the slab until it is coated. The cement-coated point is then introduced into the canal and pushed to place so that its thick end is level with the incisal edge or the point from which the measurement with the measuring device was taken. Other points may be condensed, by using a gutta-percha spreader, until the canal is packed solid.

A radiogram is taken and processed immediately to verify the accuracy with which the canal has been filled. Slight adjustments might be made after the radiogram is seen, to compensate for discrepancies, but this is seldom required. The excess cement and gutta-percha points are removed with a hot plastic instrument to a point just apical to the cervical line of the tooth. Exercise great care in removing all traces of the cementing medium from the pulp chamber with chloroform or zylol. Cementing medium left in the crown will discolor the tooth. Seal the lingual orifice in the crown with white cement until the next visit. Silver points are extremely satisfactory, when used in conjunction with a cementing medium to obliterate the root canal, but it must be borne in mind that if a post restoration is planned, the silver point must be fractured off in the apical third and the balance of the canal filled with gutta-percha. In a fractured anterior tooth, a post is almost invariably used in the final restoration.

Obliteration of the canal—open root apex.—The ob-

literation of the root canal is essential to successful endodontic treatment. The tooth with a fully formed root presents no great difficulty when the root canal must be obliterated. The tooth with the wide-open root apex presents a serious problem. Various technics, such as the sectional, the wax paste and the copper amalgam methods, have been suggested as a means of obliterating the so-called open apex canal, but all have failed

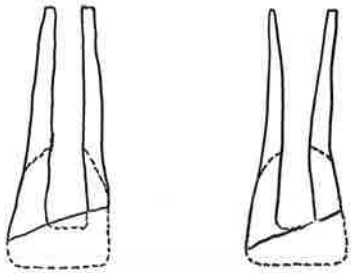

FIG. 64 *(left)*.—Open apex, cylinder type.
FIG. 65 *(right)*.—Open apex, divergent type.

because there was no certainty that the root canal was hermetically sealed. The lateral condensation of measured gutta-percha cones appears to provide the most convenient and safest technic for a satisfactory result.

The exact length of the tooth must be ascertained and recorded on the patient's chart. By means of a root canal file, fitted with a suitable measuring device which is adjusted to the incisal edge of the tooth, the tooth length can be established by x-ray. Every gutta-percha cone to enter the root canal must be cut to the exact length of the tooth. The inner wall of the root canal,

which has been previously rendered sterile, is coated with a sealer cement before the initial gutta-percha cone is placed.

Two types of incompletely formed root canals are most in evidence: the cylinder type and the inverted or divergent type (Figs. 64 and 65). The cylinder type of canal is obliterated by placing fine and extra fine gutta-percha cones within the root canal and condens-

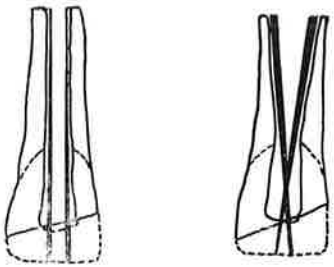

FIG. 66 *(left).*—Placement of initial gutta-percha cones in cylinder-type canal.

FIG. 67 *(right).*—Placement of initial cones in divergent-type canal.

ing to place under lateral pressure by means of a steel gutta-percha spreader (Fig. 66). This spreader must be fitted with a rubber stop, set at the length of the tooth, to prevent the point of the instrument from passing beyond the apex of the tooth. The divergent-type canal is converted to a cylinder by placing one or two large, inverted gutta-percha cones within the root canal before adding the finer cones under lateral condensation (Fig. 67). With *every* gutta-percha cone cut to the exact length of the tooth the dentist need only watch

the incisal edge of the tooth. If a cone passes above the incisal edge he knows that it has passed beyond the apex an equivalent distance. He can then withdraw the cone and continue condensation. One important warning should be observed. Do not attempt to place a large cone in the canal with the large end toward the incisal edge. The bulk of gutta-percha at the coronal orifice will be so resistant that the spreader will not reach the apex, and proper apical condensation cannot be achieved. A case of the cylinder type is illustrated in Figures 68-71.

The final step is application of a gold-backed porcelain veneer crown with a post or a porcelain jacket crown over a preparation on the remaining crown structure, which has been reinforced by a post in the root.

Nonvital Tooth–Pulp Chamber Opened by Fracture: Class 4, Division 2

Many possibilities may be encountered in these cases. Almost certainly, a large area of coronal structure is lost. The root of the tooth may or may not be fully developed, depending on the age when the accident occurred. The child probably sought emergency treatment at the time of the accident, but this was not entirely satisfactory. However, the tooth remained asymptomatic despite the fact that it became nonvital and a gangrenous pulp discharged freely into the oral cavity. Youngsters with such teeth have been seen who had been advised to wait until they were older because they were "too young yet to have anything done."

FIG. 68 *(top left).*—Two fractured central incisors in a child aged 8, showing open apices.

FIG. 69 *(top right).*—Same case, six months later. Right central incisor: successful pulpotomy. Left central incisor to be root-filled.

FIG. 70 *(bottom left).*—Determining length of the pulpless left central incisor.

FIG. 71 *(bottom right).*—Left central incisor with open apex successfully root-filled.

(Courtesy of Dr. G. C. Hare.)

Such a case is illustrated in Figure 72. Three teeth were involved; the pulps were exposed by the accident in all three teeth, but the patient was told he was "too young to do anything now." Two years had elapsed since the accident when this photograph was taken. Now the teeth are badly infected, there is

FIG. 72.—The result of neglect.

intense discoloration of what remains of the crowns, and it is probable that the bone beyond the apex is infected. Not all of these teeth can be saved. They present several additional complications not seen in class 4, division 1 cases. We must reduce the gangrene-filled root canal to a condition of asepsis; we must eliminate an area of infection beyond the apex of the root, as shown by a radiolucent apical area in the radiogram; we must overcome the discoloration in the remaining tooth structure; and when it comes to a restoration, there may be insurmountable problems because of movement of the tooth, as shown in Figures 21 and 22 (p. 56).

A careful diagnosis is required in these cases, as in all others, after the facts are recorded and the clinical examination is made.

Indications for treatment.—(1) If the tooth in question is still useful, can be rendered aseptic and will not harm the host by its presence in the mouth, it should be given treatment. (2) If the patient is young and healthy, the prognosis for successful treatment is favorable. (3) If not more than one fourth to one third of the apical periodontal tissue is lost, with the addition of root surgery the tooth may be saved. (4) If a satisfactory restoration can be placed on the remaining crown structure, the tooth may be saved provided all other factors are favorable. (5) Apical development of the root canal must be favorable to placement of a root canal filling.

Technic.—The principles of asepsis discussed under treatment of division 1 cases (p. 106) must be adhered to in division 2 cases, even though at the outset the canal is infected.

At the initial appointment ample access is obtained to the coronal portion of the pulp chamber. The superficial debris is cleaned out with spoon excavators, but the root canal is not entered to clean out debris. Any material pushed beyond the apex at this stage may compromise an already difficult situation. A short piece of absorbent point medicated with a mild, nonirritating germicidal drug, e.g., camphorated paramonochlorophenol, is placed in the coronal portion of the pulp chamber. The first dressing should be sealed in the canal with cement for not longer than 48 hours.

With the sealing of the tooth the first time, the patient must be warned that at the first sign of discomfort, the dentist should be informed.

At the second appointment, a strictly aseptic procedure must be followed. This includes use of the rubber dam and sterilization of the field of operation. The canal is opened and the dressing point is removed. The canal may be washed out with one of the chlorine preparations, such as chloramine, Dakin's solution or chlorinated soda and hydrogen peroxide used alternately. More extensive cleaning and reaming of the root canal may be done at this time, remembering always the danger of pushing anything beyond the apex. The mechanical cleansing of the canal is extremely important and must be completed as soon as possible, yet not to the point of pushing infection beyond the apex. At this sitting the root canal should be carefully enlarged by means of reamers and files to the required diameter, in order that all necrotic material may be removed and space provided for adequate medication. Prove the length of the tooth by x-ray. One or two short absorbent points are saturated with a suitable medicament to advance the chemical disinfection of the canal a stage farther. Camphorated paramonochlorophenol may again be used at this visit, or the polyantibiotic suspension (P.B.S.C.) suggested by Grossman[1] may be used to advantage. This is sealed in the canal with great care and left for 48–72 hours.

At the third appointment open through the cement seal under strict aseptic conditions. If the root canal

appears free from odor and exudate, a dry sterile absorbent paper point may be placed in the root canal for *one* minute. The paper point should then be dropped into a suitable broth medium and the tube left in the incubator for 48 hours. A drug, e.g., beechwood creosote, should be substituted for the camphorated paramonochlorophenol according to the principle of drug rotation. However, if polyantibiotic suspension is used it is not necessary to make a change, and another dressing of the antibiotics is sealed in the root canal under a double seal of gutta-percha and cement.

At subsequent appointments the procedure is repeated until two consecutive negative cultures are obtained. Quick results are usually obtained by changing the dressings every 48–72 hours.

When two consecutive negative cultures are obtained, the canal may be prepared finally for receiving a filling. Every step outlined in the procedure for filling the canal of the tooth which originally had a vital pulp will be repeated for this tooth which has now been rendered aseptic. Great care must be exercised if success is to attend the results. We repeat that root canals can be filled completely to the apex if a systematic procedure is adopted and accurate measurements are recorded for the tooth to be filled.

Some cases in this group are complicated by a small area of destruction at the apex of the tooth even after root canal therapy has been completed. In some cases the periodontal tissues are detached from the root surface and it is possible that residual infection

remains beyond the root apex. To eliminate infection from the apical region of such a tooth, root resection, or even no more than root curettement, is indicated.

Figure 73 shows the condition after root therapy had been completed; root apex curettement was performed, with the results shown in Figure 74

FIG. 73 *(left).*—Maxillary right central incisor with apical bone destruction.

FIG. 74 *(right).*—Same tooth, three years after root apex curettement.

nearly three years later. Coolidge[5] and Moen[6] report microscopic evidence to show that if the periodontal membrane reappears around the apex of a root-filled tooth, as in the case in Figure 74, new cementum has been deposited over the end of the root apex and healing has presumably taken place.

Much evidence in support of the wisdom of root resection can be found. Federspiel[7] writes that root

end amputation is indicated "especially on single rooted teeth, provided, of course, the pathological findings do not involve more than one third of the root at the apical area."

The final restoration for the cases in division 2 is similar to that suggested for the root-filled teeth in division 1.

Nonvital Tooth—Pulp Chamber Not Opened by Fracture: Class 4, Division 3

The course of events which is likely to follow within the pulp when a tooth receives a blow has already been discussed. It was stated that the prognosis for recovery of the pulp from shock was less favorable when normal development of the root had restricted the apical foramen. It was also suggested that when no crown structure was fractured off by the blow, the pulp injury was greater because the tooth absorbed the full impact of the force. Many such teeth subsequently become nonvital. This may happen soon after the incident or not until years later. The course of events is unpredictable. Often nonvitality is discovered only because of a suspected slow change in color or translucency of the crown or during a routine radiographic examination. Seldom are such cases revealed because of discomfort experienced by the patient.

Occasionally, this type of tooth takes on an intense pinkish discoloration immediately after the accident which indicates clearly the extent of the congestion

FIG. 75 *(top).*—Fractured maxillary right central incisor.
FIG. 76 *(bottom left).*—Same case, six weeks later. Incisor is nonvital and a radiolucent area has developed.
FIG. 77 *(bottom right).*—Same case, one year after root canal therapy. The radiolucent area disappeared without root resection.

within the pulp in that tooth. In most cases the course of events which follows congestion is definite. A state of nonvitality of the pulp is soon evident. The pinkish discoloration changes to a dead gray, but no symptoms of pain are described, except possibly in the very early stages, when thermal reactions may be reported. A radiogram of the tooth may show rapid development of an area of radiolucency around the apex and stripping of the periodontal membrane.

This is not always the case, however. Figures 75–77 illustrate a case followed through the stages of congestion which developed immediately after the accident; six weeks later a definite radiolucent area had developed (Fig. 76). In discussing a similar case seen in a New York hospital, Glucksman[8] describes how normal vitality returned seven months after the accident. "During this time," he writes, "the tooth turned dark because of extravasation of blood into the dentinal tubules. The condition gradually cleared up and the tooth after one year is the same shade as the unaffected teeth on either side of it."

When considering treatment for a tooth with nonvital pulp and an area of radiolucency already developed at the apex, a new and interesting problem is presented. What is the nature of the breakdown which has occurred in the apical bone, and is it infected? Unlike the example in Figure 76, often there is no break in the crown structure, no filling elsewhere in the tooth, and therefore no possible entrance for bacteria through exposed dentinal tubules (Fig. 78). These teeth often cause no discomfort to the

FIG. 78.—Mandibular central incisors with radiolucent areas at the apexes. Reactions to vitality tests were negative. There has been no discomfort in the 10–12 years since the accident.

FIG. 79.—Five years after injury to anterior teeth which caused loss of the maxillary left central incisor. There was no history of pain until recently, when abscesses of the central incisors developed. Note extensive breakdown at the apex of the left central incisor, with cyst formation.

host and the question arises, particularly when no radiolucent area is evident, whether they should be interfered with. Once in a while the elements in the apical region become cystic, and extensive loss of bone may result from one of these symptomless conditions (Fig. 79).

The author has had occasion to open a number of such symptomless nonvital teeth, in which no loss of crown structure had occurred and a radiolucent area was present or, in some cases, no radiolucent area was evident. Strictly aseptic operating conditions were maintained throughout the procedure and culture mediums were inoculated with the contents of the canals. The limited evidence available from this work suggests that few of the regular active organisms are present in the root canals, even though in some cases moist gangrene with a putrescent odor was encountered. An observation by Lundquist and Kellogg[9] relevant to this may be cited at this juncture. They write: "It seems wise to consider the fact that all rarefied areas as viewed on the basis of roentgenographic evidence are not necessarily infected."

What then are the implications in the treatment of these teeth and what is the prognosis for them?

Technic of treatment.—Many of us have had the embarrassing experience of opening a symptomless, nonvital tooth and, under aseptic conditions, carefully sealing a dressing in the canal, only to find that within 24–48 hours the tooth has all the earmarks of the early stages of an acute abscess. The patient is surprised, because the tooth was comfortable before

the intervention. Has the canal of the tooth been infected, or has an organism lying latent in the sealed tooth been activated? These questions are unanswered, but the facts are that, clinically, this is not an uncommon experience with these closed nonvital teeth. At present, the view is generally accepted that a nonvital tooth should have a root canal filling to obliterate the canal, irrespective of the contents of the canal on initial examination, provided due respect is held for the principles of maintenance of general health. On that premise we advise root canal therapy for these teeth as soon as they are discovered.

Every phase of treatment must be confined within the limits of strict asepsis. Isolation of the tooth with rubber dam and sterilization of the field of operation and careful preparation and sterilization of every instrument and dressing to be used are vitally important to success. Special mention must be made of the inflammatory reaction which may follow the cementation of the dressing in the canal after initial opening. The patient should be warned of this possibility and, even though the second appointment follows within 48 hours, should be instructed to report any marked discomfort. To eliminate all possible exciting causes of this initial inflammatory reaction, care must be exercised when the pulp chamber is opened and the first dressing placed to avoid pushing anything beyond the apex of the root or allowing any irritating drug to reach the apical tissues. Under no circumstance should any instrument be passed into the root canal at this visit. The first dressing should consist of a pledget of

sterile cotton moistened with a medium strong germicide, such as camphorated monochlorophenol, sealed in for 24–48 hours. Subsequent treatment will follow a plan similar to that outlined for division 2 cases (pp. 117 ff.), with the number of treatments required depending on how rapidly two consecutive negative cultures can be obtained.

The root canal filling used is similar to that recommended for the types previously discussed in this chapter.

In division 3 cases in which there is a radiolucent area immediately adjacent to the root apex of the tooth, it is impossible to determine what the course will be. Figure 76 illustrates an area that had developed rapidly after the accident. A year after insertion of the root canal filling there was evidence of a tendency to reorganization of the area and regeneration of the bone structure (Fig. 77). Figure 80 illustrates a similar case at the time the lower four anterior incisors received a severe blow from a hockey puck. Six months later the left central incisor failed to respond to vitality tests and the routine radiogram revealed a radiolucent area (Fig. 81). No discomfort had been experienced by the patient in the meantime. The crown structure lost as the result of the accident was limited to a minute fragment of incisal enamel.

Figure 82 shows a radiogram of the same tooth 11 months after a very mediocre root canal filling had been placed and 13 months after Figure 81 was made. Less than 18 months after the root canal was filled,

FIG. 80 *(above).* — Mandibular incisors at the time of severe displacement of all four teeth (March, 1937).
FIG. 81 *(right).* — Same case, December, 1937.

FIG. 82 *(left).*—Same case, January, 1939. Root canal was filled in February, 1938.
FIG. 83 *(right).*—Same case, December, 1940.

the area had reorganized completely; Figure 83 was made four years after the initial accident. It is interesting to note the almost complete obliteration of the canals in the adjacent teeth in this case (compare Figs. 80 and 83). This condition was referred to in Chapter 2.

As the result of extensive clinical experience, a period of watchful waiting is suggested once the root

FIG. 84.—Discoloration resulting from nonvitality.

canals are filled. This admonition applies only to division 3 cases, in which there is little or no loss of crown structure and the tooth is nonvital and symptomless. Again we are reminded by this type of case of the extraordinary powers of recuperation of the tissues of the young patient.

A restoration.—Because division 3 of the class 4 cases is concerned only with nonvital teeth in which little or no tooth structure is lost, any discussion of the type of restoration recommended may seem unnec-

essary. However, the problem of discoloration of the tooth structure is vital. The amount of tooth structure actually lost may not necessitate replacement, but the color of the remaining tooth structure may demand attention. Figure 84 shows this kind of problem, and also some loss of the incisal edge, mainly by grinding. The latter complication may not be present, and the problem is then one solely of discoloration.

Treatment of the discolored tooth which requires no restoration resolves itself into (1) bleaching or (2) replacement of the crown by an artificial restoration.

1. Bleaching. Discolored nonvital teeth can be restored to normal appearance if careful attention is given to the bleaching technic. The results are only relatively permanent and must not be considered to be absolute.

Preparation of the tooth for the bleaching treatment is extremely important. Any surface stains on the tooth to be treated should be removed first by regular prophylactic measures. A protective film of petrolatum is then applied to the mucosa surrounding the tooth to be bleached. Isolate the six anterior teeth. In this way the shade comparison is constantly noted. Any restorations in the exposed teeth should be coated with petrolatum or cocoa butter. The rubber dam must be held in place and sealed at the gingival crevice with a double ligature. This precaution is taken because leakage of the strongly caustic bleaching agents into the gingival tissues would inflict serious destruction. All fillings must be removed from the crown of the tooth,

because the bleaching agent will destroy them if they remain in place and the salts produced in the disintegration of such fillings may cause further discoloration. If a root canal is filled with metallic points, the points should be reduced to the level of the cemento-enamel junction with a carborundum point or large round bur and then sealed over with a good oxyphosphate cement. Protect the patient's clothing with a surgical apron.

All debris and stained areas within the pulp chamber should be removed by mechanical means, following which the tooth should be washed with distilled water and thoroughly dried. Assurance of dehydration of the prepared crown may be obtained with the use of a medicament or combination of suitable agents, such as

Chloroform	1 part
Ethyl alcohol	3 parts

This completes the preparation of the tooth for bleaching. The agents used in the bleaching process possess either powerful oxidizing or reducing properties and are strongly caustic. Among the many that have been used, pyrozone is very effective. It is 25 per cent hydrogen peroxide in ether and is provided in sealed and dated glass vials. It is advisable to wear rubber gloves to protect the hands from accidental exposure to the bleaching drug. The vial must be opened carefully, preferably held in a cold damp towel while a nick is made in the neck with a file and the top removed. A few drops are poured in a dappen

glass for direct use, and the opened vial is stood in a drinking glass. Under no circumstances should either the dappen glass or vial be placed on the operating tray or anywhere within range of the patient for fear of accidental spilling. As an additional precaution, whenever pyrozone is in use, the petrolatum or Tangel should be close at hand. An area burned with pyrozone should be quickly washed off with water and petrolatum smeared over it.

Into the prepared pulp chamber is placed a small bundle of cotton fibers, with the end of the bundle of cotton extending out on the tooth surface like a wick. The crown of the tooth is enveloped in cotton. The embalmed crown is then saturated with pyrozone, carried to the cotton in a glass dropper. No steel instruments should be used or allowed to come in contact with the pyrozone. Heat and light are effective aids in the bleaching action. A no. 1 photoflood lamp with a reflector is focused on the tooth from a distance of 2 ft. The patient's eyes must be protected with dark glasses, and the operator may find it necessary to shield his eyes similarly. A 10–15 minute exposure to the light should effect marked improvement in the tooth at the first treatment. During this period, it is essential that a drop or two of pyrozone be added from time to time.

The cotton is removed, and the canal and tooth are washed with distilled water and dried. It is recommended at this stage that colorless temporary stopping be placed in the pulp chamber and the tooth sealed with cement. A second treatment may be considered

advisable, but such a decision should be made only after a 48–72 hour interval.

The final phase of the bleaching operation is concerned with restoration of translucency to the tooth. Chloral hydrate (80 per cent in water) has been found most useful. The tooth is isolated with rubber dam and dehydrated carefully with alcohol. The pulp chamber is flooded with chloral hydrate, and, if it is possible to seal the opening, pressure is applied to force the chloral hydrate into the dentin tubules as it is applied in pressure anesthesia. After five minutes of this treatment, the excess medicament is dried out and the dentinal tubules are sealed with a clear varnish. A restoration for the tooth completes the case.

2. Restoration. When bleaching is unsuccessful or perhaps not attempted, treatment of a discolored crown assumes a more radical form. The various types of restorations which may be employed include (1) the post-acrylic crown, (2) the post-jacket crown and (3) the gold inlay with acrylic labial veneer. The first two are advocated when the crown of the tooth is fractured extensively and the remaining crown stump is further weakened because of the nonvital status. The gold inlay with the acrylic veneer is advocated when a considerable part of the natural tooth crown remains.

The Post-Acrylic Crown. The outstanding results being obtained today by endodontic treatment provide an excellent prognosis for the pulpless tooth. Therefore it is wise to plan the restoration of the crown of the root-filled fractured anterior tooth in the young patient

so that it will be strong and esthetically satisfactory and so that it may be repaired or changed easily at a later date. The post-acrylic crown meets all these requirements.

The preparation of the crown is not difficult. If little of the natural crown remains it is expedient to remove the entire crown. Carry the labial aspect 1 mm. under

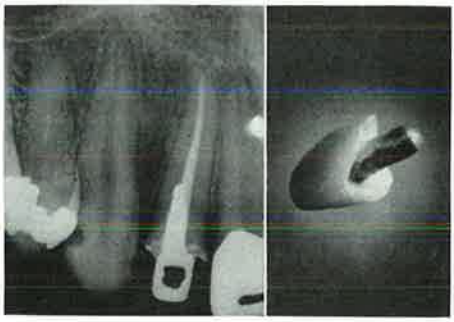

FIG. 85 *(left).*—Gold post and hollowed anterior crown core a post-acrylic crown.
FIG. 86 *(right).*—Post-acrylic crown for extensive crown restoration of a young tooth.
(Courtesy of Dr. J. B. Pepper.)

the gingival margin. If any portion of the natural crown is to be retained, all the enamel must be removed. The labial face of the preparation must provide ample space for plastic, so that masking the root stump will not become a problem in constructing the crown. The root filling is removed for about one half the root length with a spoon excavator. The use of a bur for this operation is contraindicated because it has a tendency to

disturb the remaining root canal filling. Taper the canal with a small diamond point of suitable diameter.

In the construction of the post crown, the post for the root canal and the restoration of any part of the crown stump is cast in one piece in hard gold. Retention for the acrylic is provided by leaving a window through the crown core (Fig. 85).

The hydrocolloid impression technic is ideal in the construction of this restoration. Suggestions for the reduction of troublesome tissue which may overlap the margins of the prepared crown stump have been made (p. 66). The impression technic using hydrocolloid has been outlined in some detail in Chapter 3.

The post crown can be waxed directly on the die seated in the model. The die, and particularly the root canal, should be lubricated with Microfilm. A small piece of Nylon bristle is used for a core to carry soft counter wax into the canal. The counter wax is used in the canal because it has been found to be more easily adapted. The coronal portion of the pattern is waxed up to simulate the crown, but smaller. The crown core is hollowed through from labial to lingual side to provide retention for the acrylic (Fig. 85). The casting is then made in hard gold.

The acrylic portion of the crown is completed in the laboratory. Figure 86 illustrates a completed post-acrylic crown ready for cementation in the mouth.

Barak[10] describes the procedure for constructing an "immediate post crown in approximately one hour" when such temporary service is required.

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CHAPTER 6 CLASS 5

Teeth Lost As Result of Trauma

Prescription for Treatment

A. Record case history (p. 25)
B. Record results of clinical examination (p. 25)
C. Diagnosis of the case; determine treatment plan
   1. Placement of a restoration—class 5, division 1
   2. Repositioning of teeth to compensate for space—class 5, division 2

Placement of Restoration—Class 5, Division 1

a) Reasons for temporary restoration
   (1) Space maintenance
   (2) Speech maintenance
   (3) Esthetics
   (4) Function

b) Types of temporary restoration
   (1) Simple space-maintainer, first type
      i) Construct pinch bands for adjacent anterior teeth
      ii) Solder wire between
      iii) Cement to place

(2) Simple space-maintainer, second type
   i) Construct pinch bands for second deciduous or first permanent molars
   ii) Adapt connecting wire contacting lingual surfaces of teeth
   iii) Solder wire to bands or fit into vertical palatal tubes
   iv) Solder spurs on lingual wire to retain anterior teeth
   v) Cement bands to place; if lingual wire is retained in tubes, position it

(3) Orthodontic bridge, first type
   i) Construct pinch bands for adjacent teeth
   ii) Solder wire between
   iii) Adapt facing and backings suitable to case
   iv) Solder backing to wire and build lingual contour
   v) Cement facings on backings
   vi) Cement bands and bridge to place

(4) Orthodontic bridge, second type
   i) Construct pinch bands for second deciduous or first permanent molars
   ii) Adapt connecting wire contacting lingual surfaces of teeth
   iii) Solder wire to bands or fit into vertical palatal tubes
   iv) Adapt facing and backing suitable to case
   v) Solder backing to wire and build lingual contour
   vi) Cement facing on backings
   vii) Cement bands and bridge to place

(5) Removable partial denture, first type
   i) Construct partial acrylic denture with full palate coverage
   ii) Use acrylic teeth
   iii) May be retained by clasps; preferably not

iv) Retention frictional against lingual surfaces of teeth
v) Relieve gingival tissues by reducing denture

(6) Removable partial denture, second type
i) Construct partial acrylic denture with "horseshoe" palatal coverage
ii) Details same as for first type

(7) Removable partial denture, third type
i) Construct clasps or cribs for second deciduous or first permanent molars
ii) Denture base to be clear of lingual surfaces of teeth (erupting)
iii) Use acrylic base and teeth
iv) Details of construction same as elsewhere

c) Designs by ages

(1) Age 8

Single tooth	i)	Removable part. dent., 1st type
	ii)	Removable part. dent., 2d type
	iii)	Orthodontic bridge, 2d type
Multiple teeth	iv)	Space-maintainer, 2d type

(2) Age 9

Single tooth	i)	Removable part. dent., 1st type
	ii)	Removable part. dent., 2d type
	iii)	Orthodontic bridge, 2d type
Multiple teeth	iv)	Removable part. dent., 1st type
	v)	Removable part. dent., 2d type

(3) Ages 10 and 11

Single tooth	i)	Orthodontic bridge, 1st type
	ii)	Removable part. dent., 3d type
Multiple teeth	iii)	Removable part. dent., 3d type

(4) Age 12

Single tooth	i)	Orthodontic bridge, 1st type
	ii)	Removable part. dent., 1st type
	iii)	Removable part. dent., 2d type
Multiple teeth	iv)	Removable part. dent., 1st type
	v)	Removable part. dent., 2d type

d) Permanent restoration (after age 15)
(1) Fixed bridge
(2) Removable denture

Repositioning Teeth to Compensate for Loss of Tooth—Class 5, Division 2

a) Indications
(1) Space partially lost before case is seen
(2) Malocclusion already evident and some realinement is necessary

b) Procedure (when one central lost)
(1) Move lateral adjacent to lost central into space of the central
(2) Place temporary-permanent central crown over lateral crown
(3) At suitable age replace temporary-permanent crown with porcelain jacket crown

Preliminary Considerations

One or more anterior teeth may be lost accidentally or because of infection resulting from injury during the mixed dentition period. Many factors complicate the replacement of these lost teeth with an artificial temporary restoration. The factors discussed here must be considered to have an important influence on the diagnosis and on the treatment plan for this type of case.

Temperament of the patient.—The type of temporary restoration to be recommended will be influenced by the temperament of the patient. The careless, irresponsible child would be an unsuitable subject for a removable restoration, that depends on cleanliness for protection of the adjacent teeth against caries. This type of child would seldom wear a removable appliance and would probably lose it or break it sooner or later. The nervous patient would probably experience a great deal of difficulty in learning to use a removable restoration.

The interested, co-operative patient, on the other hand, will amaze one with the satisfaction derived from a restoration which superficially appears to lack adequate retention.

Age as it affects degree of eruption of teeth.—During the mixed dentition period, the stage of eruption of the various teeth differs according to developmental conditions. Because the physiologic age of the child does not always coincide with the chronologic age, it is difficult to define the development at various ages. Figure 2 (p. 26) shows diagrammatically the development of the mixed dentition at different ages as conceived by Schour and Massler. These sketches reveal the normal average for specific ages. The design of any restoration to be placed in a mouth during the period of development will be affected by the stage of eruption of the teeth. Enlarged swollen tissues surrounding erupting teeth must be cleared.

Degree of development of roots of permanent teeth. If permanent teeth are to be used to stabilize or aid

in the retention of a restoration designed to replace lost permanent anterior teeth, the degree of development of the roots must be known. A tooth used for retention or stabilization must not be overloaded before root development is sufficient to support it. We suggest that the first permanent molar must not be used until the child is 8½ or 9 years old and should be used then only if the child's physiologic age is abreast of the chronologic age, as shown radiographically.

Degree of absorption of roots of deciduous teeth.—Linked closely with the eruption of permanent teeth is the complementary process of absorption of the roots of the deciduous teeth. The normal physiologic process of exfoliation of the deciduous teeth must not be interfered with by any restoration placed in the mouth. Once absorption of the roots reduces the support for these teeth, they must not be overloaded. The second deciduous molar has been suggested by some authors as a useful retaining tooth. Beyond the age of 9 the normal root support left for this tooth is insufficient to warrant its continued use. Fortunately, this is the age at which it is deemed safe to rely on the first permanent molar.

Degree of susceptibility to caries.—The caries susceptibility factor is relatively important when considering the type of restoration for lost permanent anterior teeth. The more complex form the restoration assumes, the greater the possibility of food stasis, which in a caries-susceptible individual would be disastrous. Even under the best conditions, the normal

natural cleansing mechanism for the teeth and oral tissues is disturbed by the insertion of an artificial restoration, whether fixed or removable. Therefore the need for special precautions in oral hygiene measures must be impressed on the young patient, and similarly on the parent. How difficult this is with the non-co-operative, careless child of equally careless parents, most of us have learned from experience.

Relationship of mandibular and maxillary teeth.— When one fails to take the bite into account, untold grief may follow. Sometimes the mandibular incisors come in contact with the tissues lingual to the maxillary incisors when in the centric position. In such a case there is little or no space to accommodate the thickness of a restoration. If this is the situation, it is probable that there is lack of vertical support in the posterior regions. Such cases are probably examples of gross or potential malocclusion. No time should be lost therefore to institute corrective measures. Consultation with the orthodontist concerning the dental arches of such children should be considered a necessity before proceeding with a restoration.

Before discussing the types of restorations that are acceptable in these cases, it must be mentioned that there are two possible alternatives in treatment for lost teeth in the young patient. First, there is maintenance of the space either by a functional type of space-maintainer or by a simple space-maintainer; second, repositioning of many teeth to compensate for the space created by the lost tooth may be effected. The latter plan involves careful diagnosis and formula-

tion of a treatment program, which must be carried to completion with precision through the well co-ordinated efforts of the orthodontist and dentist. This aspect of treatment will be discussed later in the chapter. The immediate concern is with maintenance of the space. A permanent restoration cannot be considered until the child is 14–15 years of age.

Placement of a Restoration: Class 5, Division 1

Reasons for a temporary restoration.—1. Space Maintenance. The space created by loss of an anterior tooth should be maintained if normal development of the rest of the arch is to take place. Compensation for the space by moving teeth either intentionally by mechanical means or unintentionally by allowing drifting to proceed unchecked will result in malocclusion. The space can be retained intact only by active intervention by the installation of some type of restoration. When a space-maintainer is used, it must be designed and constructed so that the normal growth and development of the arches proceeds unhindered. Loss of teeth occurs often during this important developmental period and mechanical interference may be detrimental.

2. Speech maintenance. Habits are acquired rapidly by children and, once formed, are usually persistent. With the loss of an anterior tooth, the mechanism for the formation of speech is interfered with in part, but the child will quickly make adjustments for the discrepancy. Such adaptation, once established, may influence the speech of that individual for life. Restora-

tion of the space is therefore indicated to prevent speech disturbances.

3. Esthetics. The psychologic importance of maintaining the normal appearance of the young patient was discussed in Chapter 1. The esthetic significance of space maintenance should not be overlooked when considering the type of restoration for a lost tooth.

4. Function. The initial restoration must be considered temporary. It is primarily a space-maintainer for maintenance of speech and esthetics; it must not be overrated as a means for restoring complete function. On this basis we may consider the type of restoration to be recommended.

Types of Temporary Restoration

1. *Simple space-maintainer (first type).*—Maintenance of the space created by the loss of one or more anterior teeth is accomplished most easily with a simple space-maintainer. When this plan is adopted, speech, function and esthetic requirements are ignored. There seems little to justify such action, but circumstances are different in every case, and this type of restoration is indicated occasionally.

When the adjacent anterior teeth are completely erupted and the root formation is well advanced (at age 10 or later), a simple space-maintainer may be constructed (Fig. 87). Pinch bands of anterior orthodontic banding material are formed for both permanent teeth adjacent to the space (the cuspid is excluded). The bands are connected by soldering to

their lingual surfaces a 0.030 orthodontic wire which will fit snugly to the alveolar mucosa. The position of the wire must be such as to clear the occlusion.

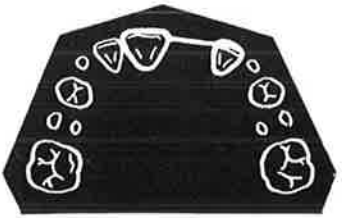


FIG. 87.—Simple space-maintainer—for age 10 or later.

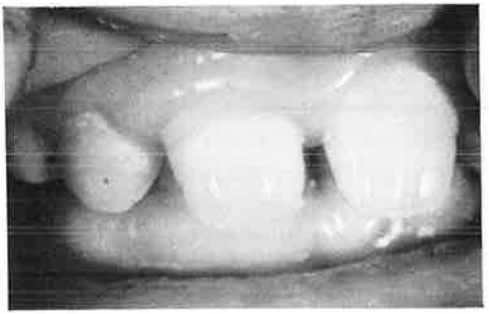


FIG. 88.—An area of decalcification beneath a loose band on right central incisor.

The appliance may then be cemented to place with copper cement. Care should be taken to instruct the patient regarding both the necessity for cleanliness while the space-maintainer is in place and the danger arising from loosening of one band. Immediate atten-

tion is required when a band becomes loose. A band fitting loosely around a tooth will cause rapid decalcification of enamel covered by the band (Fig. 88).

A modification of the simple space-maintainer has been suggested by some operators. It is designed (1) to retain partially the individual freedom of normal physiologic movement of the banded teeth and (2) to obviate the possibility of one band becoming loose

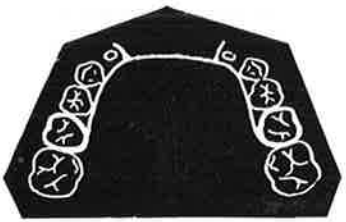


FIG. 89.—Simple space-maintainer—for ages 7—10.

unnoticed. Instead of soldering the connecting wire at both ends, one is left free and is received in a tube or loop attached to the band on the adjacent tooth.

2. *Simple space-maintainer (second type).*—When the adjacent anterior teeth are not completely erupted or when deciduous teeth are adjacent to the space, the problem is more difficult. Space may be maintained in such cases by banding the second deciduous molars in children under 9 years or the first permanent molars in children over 9, and connecting them with a 19 gauge orthodontic wire (Fig. 89). The ends of the wire may be soldered to the bands, but preferably not. The attachment to the bands should be such that

adjustment can be made readily from time to time. Vertical orthodontic tubes are soldered to the bands on the lingual surface, and the ends of the lingual wire connecting the bands fit into the tubes. Locks may be required to keep the arch wire in the tubes. The connecting wire should fit snugly to the tissues and reasonably close to the lingual surfaces of the teeth. From the anterior section of the lingual wire, spurs are positioned to retain the teeth adjacent to the anterior space. The appliance must be carefully and accurately constructed so that it will be a space-maintainer only, and not an active orthodontic appliance. Repeated inspection and adjustment of the appliance should be part of the treatment. At a suitable time the design of the restoration may be changed.

3. *The orthodontic bridge (first type).*—The logical development of the simple space-maintainer in order to fulfil more of the physiologic requirements of a restoration for lost anterior teeth is the orthodontic bridge. The two methods of construction of the space-maintainer have already been mentioned.

When the adjacent teeth are fully erupted and the roots well developed, bands are made and a connecting wire of 0.030 gauge joins them. To this wire, the backing for a porcelain facing of suitable shade, size and mold is soldered after the facing has been adjusted to fit the gingival tissues accurately. The facing or facings are cemented to the backings with a suitable oxyphosphate cement. The finished, polished orthodontic bridge is cemented to place with black copper cement. Again careful warning should be given

to the patient concerning oral hygiene and the danger of the bands becoming loose. The restoration described (Fig. 90) not only retains the space but also restores normal speech and function.

The metallic bands anchoring the bridge to the adjacent teeth leave much to be desired from the standpoint of esthetics. Again we stress the point that failure to regard this factor has an important effect

FIG. 90.—Orthodontic bridge restoration, for use when adjacent teeth are fully erupted.

on the child's mental outlook and may lead to the development of complexes that will handicap him in the future. Adjustment of the anchor bands and replacement of a portion of them with acrylic, for esthetic reasons, are justified provided the requirements of strength are maintained. This consideration applies equally to the designs shown in Figures 105 (p. 165), 108 (p. 167) and 111 (p. 169).

4. *The orthodontic bridge (second type).*—The second method outlined for the construction of a simple space maintainer was designed for use when the anterior teeth adjacent to the space were not erupted fully or were otherwise unsuitable for banding. Here

again, a backing may be soldered to the lingual wire and porcelain facings selected and adjusted and cemented to place to complete the orthodontic bridge (Fig. 91). However, it must be stressed that the span from the anchorage point in the molar region to the restored tooth is long and such a restoration must be given great care and should be examined frequently.

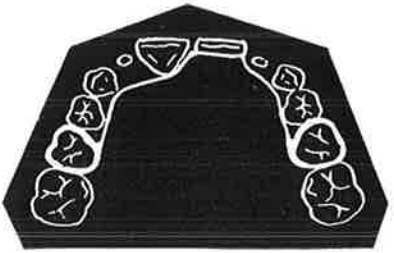


FIG. 91.—Orthodontic bridge restoration, for use when teeth adjacent to the lost tooth are not fully erupted.

Overlay bridges. Other modifications of bridgework have been suggested for temporary restoration of a lost anterior tooth. Because of the nature of the preparations made for the abutment teeth they are referred to as "overlay bridges." The overlay abutment is a modified three-quarter crown. The preparation of the tooth for the overlay abutment is limited, as required by the basic principles of pulp conservation in young teeth. Use of these overlay bridges is not recommended if one of the many other types of restorations for lost teeth can be adapted.

5. *The removable partial denture (first type).*—As temporary restorations, various types of partial den-

tures have been used. The problems of retention and stabilization of a removable restoration during the period of eruption of permanent teeth and exfoliation of deciduous teeth are difficult. The progressive growth changes of the arches in width, height and anteroposterior direction introduce the need for continual adjustments to keep pace with the natural

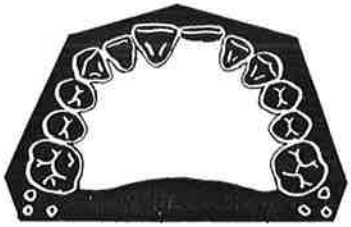


FIG. 92.—Removable partial denture design, with full palate coverage, preferably without clasps.

development. There are three commonly accepted designs for the partial denture.

The first design, recommended by some operators, includes full palate coverage with or without clasps or cribs for retention. The majority favor construction of these restorations without clasps (Fig. 92). The partial denture of this design is retained at first by frictional retention against the lingual surfaces of the permanent and deciduous teeth. If this initial frictional retention retains the denture for only a few weeks before it is lost, owing to movement of the teeth, its purpose has been fulfilled. At the end of a few weeks the patient has learned to retain the den-

ture by muscle, tongue and lip action. The denture material in contact with the gingival tissues around the teeth should be relieved to prevent injury to the periodontal tissues. A denture of such simple design is perhaps the least complicated of all those to be suggested and, despite its simplicity, has given a large measure of satisfaction. Indeed, during observation of many of these cases, we never cease to wonder how the children can retain some of the ill-fitting restorations that we see. It is not to be inferred from this statement that the restorations were ill-fitting when originally inserted; the condition is due to growth and development of the arch and failure to make the adjustments necessary to refit the denture at regular intervals. The denture should be made extremely thin so that it will interfere with speech just as little as possible. The use of acrylic teeth and acrylic denture base material is advocated because of strength, lightness and all-round efficiency. The details of impression-taking, recording the bite, setting the teeth and processing the denture are not discussed in this manual.

Those who advocate the use of clasps or cribs for retention do so with the knowledge that they must be carefully adapted and will have to be adjusted from time to time. If they are placed at an early age and left unchanged during the period of growth and development, they will have a marked constricting influence on the arches. A compromise can be made as far as clasps for retention are concerned by placing them on the denture and removing them as soon as

the initial testing period is over. After the patient has become accustomed to the denture, they are no longer needed. When used, the palatal portion adjacent to the teeth may be cut away from the teeth.

6. *The removable partial denture (second type).*—The second design is sometimes referred to as the "horseshoe" type of partial denture (Fig. 93). The

FIG. 93.—Horseshoe type of partial denture.

difference between this denture and the full palate type lies in the palatal coverage. More tongue room is gained by reducing the area covered by the denture. One factor which must be studied carefully in the horseshoe type is the actual line on which the posterior periphery is finished. Its relation to the palatal rugae should be such that the border of the denture will be in a trough between two rugae elevations. There is a tendency to weakness inherent in the shape of the horseshoe denture, and more repairs may be required than with the full palate type. For several reasons, therefore, the horseshoe-shaped partial restoration is inferior to the full palate type.

7. *The removable partial denture (third type).*—In the foregoing discussion of partial dentures it was suggested that clasps are preferably dispensed with. It was also pointed out that when clasps were used with the full palate denture the denture base material could be cut away from around the teeth, leaving the gingival tissues free. This is almost essential when teeth are erupting and there is some fulness and

FIG. 94.—Removable partial denture design, with mechanical retention.

inflammation of the soft tissues. Under these circumstances clearance of the congested tissues is essential. The third type of partial denture recommended is similar to the denture which is retained by clasps and covers the full palate, but wide relief is given the gingival tissues by cutting back the denture base. Morgan uses this type of restoration, retained not by clasps but by Crozat cribs on either the second deciduous molars or the first permanent molars (Fig. 94).

It must be pointed out that the arbitrary classification of the designs for lost anterior teeth presented

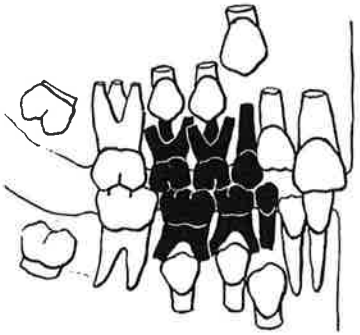
on pages 149-169 is subject to many variable factors, and each case must be properly diagnosed before a treatment plan is decided on. This classification, therefore, can be used only as a guide when studying a case.

Designs According to Average Age

AGE 8 YEARS

At 8 years of age the lateral incisor is erupting. The three deciduous teeth mesial to the first permanent molar are present, little resorption having taken place as yet. On the opposite page are shown three designs for restoration of one central incisor: the full palate partial restoration (Fig. 96), the horseshoe type (Fig. 97) and a fixed orthodontic bridge which depends on the second deciduous molars for retention (Fig. 98).

When two central incisors are lost at this age, the designs shown in Figures 96 and 97 are not suitable. Even that shown in Figure 98 is of questionable value because the laterals are erupting and two artificial central incisors flanked by erupting laterals may not be tolerated by the tissues. Under these circumstances a space-maintainer (Fig. 99) for a year will be efficient.



8 YEARS (±9 MO.)

FIG. 95.—Eruption of teeth at the age of 8. (Courtesy of Dr. I. Schour and Dr. M. Massler.)

FIGS. 96 AND 97.—Designs for restoration of one lost anterior tooth at the age of 8.

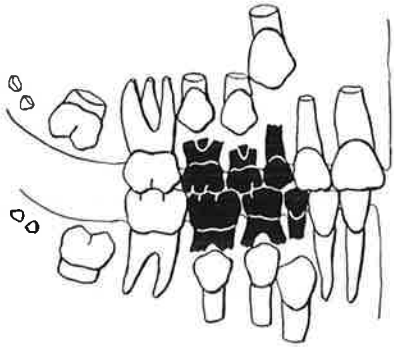
FIG 98 *(left)*.—Design for restoration of one lost anterior tooth at the age of 8.
FIG. 99 *(right)*.—Design for restoration of several lost anterior teeth at the age of 8.

AGE 9 YEARS

At 9 years the lateral incisors have erupted almost completely into position. The roots of the three deciduous teeth are half absorbed and should not be used for retention. The first permanent molar roots are well on the way to complete development.

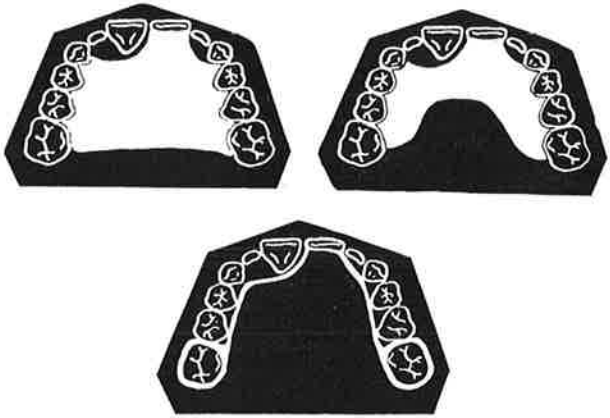
The loss of one central incisor at this age might be taken care of with a full palate restoration (Fig. 101), a horseshoe type of restoration (Fig. 102) or an orthodontic bridge anchored on the first permanent molars (Fig. 103).

When two central incisors or a lateral and a central incisor are lost, the horseshoe type or full palate partial restoration may be used, but an orthodontic bridge is contraindicated.



9 YEARS (±9 MO.)

FIG. 100.—Eruption of teeth at the age of 9. (Courtesy of Dr. I. Schour and Dr. M. Massler.)

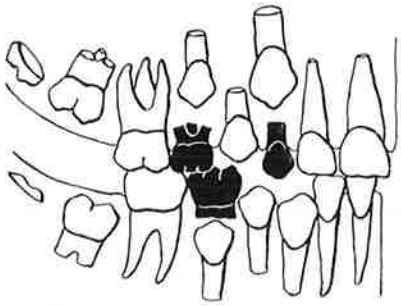


FIGS. 101–103.—Designs for restoration of one lost anterior tooth at the age of 9.

AGE 10 YEARS

At 10 years, with the lateral incisors fully into position, it is possible to use the simple space-maintainer or the simple orthodontic bridge (Fig. 105). Because of erupting first bicuspids and deciduous teeth with the roots almost absorbed, a partial denture must be kept clear of these teeth. Therefore the Morgan type of restoration is advisable (Fig. 106).

When two central incisors or a central and a lateral incisor are lost, the design shown in Figure 105 would not be satisfactory. That shown in Figure 106 would not be ideal for the replacement of more than two anterior teeth.



10 YEARS (±9 MO.)

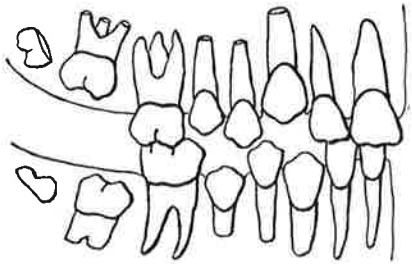
FIG. 104.—Eruption of teeth at age of 10. (Courtesy of Dr. I. Schour and Dr. M. Massler.)

FIGS. 105 AND 106.—Designs for restoration of one lost anterior tooth at the age of 10.

AGE 11 YEARS

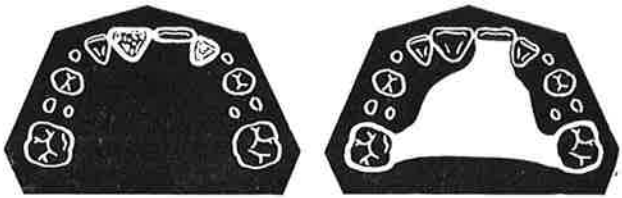
At 11 years the cuspid and second bicuspid are erupting and the first bicuspid is nearly into position. The restoration of one tooth at this age is similar to that designed for the 10 year old patient (Figs. 108 and 109; compare with Figs. 105 and 106).

The same consideration applies in replacement of two anterior teeth at this age.



11 YEARS (±9 MO.)

FIG. 107.—Eruption of teeth at the age of 11. (Courtesy of Dr. I. Schour and Dr. M. Massler.)

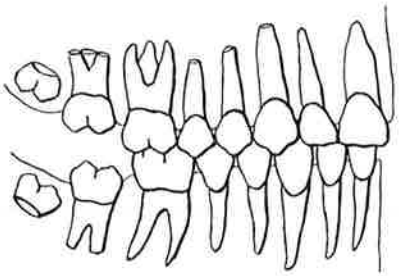


FIGS. 108 AND 109.—Designs for restoration of one lost anterior tooth at the age of 11.

AGE 12 YEARS

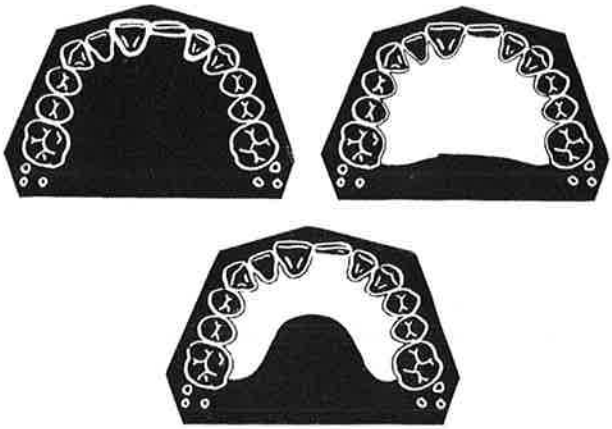
At 12 years all permanent teeth back to the first permanent molars are in position, and the second permanent molar may be in place too.

Besides the orthodontic type of bridge (Fig. 111), the full palate (Fig. 112) and the horseshoe (Fig. 113) partial restorations may be used with or without clasps. If several teeth are lost, a partial denture restoration is indicated.



12 YEARS (±6 MO.)

FIG. 110.—Eruption of teeth at the age of 12. (Courtesy of Dr. I. Schour and Dr. M. Massler.)



FIGS. 111–113.—Designs for restoration of one lost anterior tooth at the age of 12.

A Permanent Restoration

The age at which a permanent restoration can be placed has been the subject of considerable debate. The ideal restoration is probably a fixed bridge. Preparation of the abutment teeth is important. In conservation of the pulp lies the greatest hope of success. A fixed bridge, using three-quarter crown abutment preparations, is the type of restoration generally advised. It seems reasonable to suppose that preparation of the anterior teeth for these abutments is relatively safe after the fifteenth year. Construction of a bridge is not discussed in detail in this manual because it is outlined in various texts.

If a fixed restoration is contraindicated, the second choice is a partial removable denture. This should be made to conform to all the fundamental principles of adequate partial denture service.

Repositioning to Compensate for Loss of a Tooth: Class 5, Division 2

Earlier in this chapter, during discussion of the various methods of handling the problem created by the loss of an anterior tooth in a child, besides the use of a space-maintaining restoration, mention was made of a program of repositioning teeth to compensate for loss of the tooth. The end-result may not be perfect, for some change in the normal relationship of cusp interdigitation is inevitable, but the results obtained in a number of cases by this method warrant its inclusion here. Unusual circumstances may predispose to a favorable prognosis if repositioning of

teeth is undertaken. When a central incisor is lost and the condition is neglected, the space quickly closes and some repositioning of the other teeth accompanies the change. It is too late in these cases to maintain the original space; to re-establish it would involve

FIG. 114.—*Top*, loss of maxillary left central incisor, with left lateral incisor moved into the resulting space. *Bottom*, restoration with a gold-acrylic central crown on the lateral incisor.

considerable treatment with orthodontic appliances.

The procedure involves aiding the movement of the lateral incisor into the space created by the loss of a central incisor and repositioning it in the place of the lost central incisor. A central crown of temporary-permanent construction is then placed on the lateral root, with comparatively good esthetic results (Fig. 114). The preparation required for the temporary-permanent crown is limited, and the young pulp in the lateral incisor is in no way endangered by

the procedure. At a suitable time later, a permanent porcelain jacket crown can be placed on the lateral incisor. The various stages in the treatment of such a case are shown in Figure 115. The symmetry of the

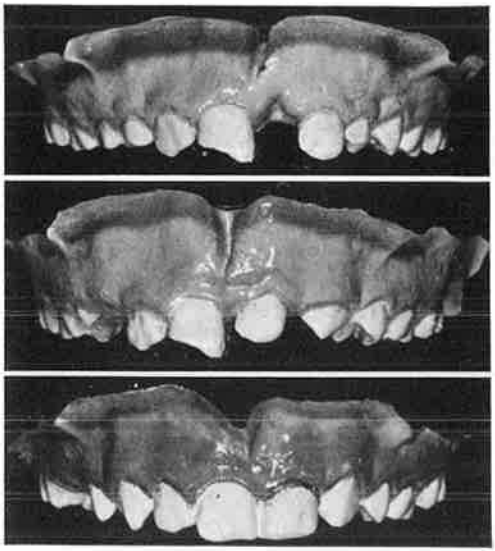


FIG. 115.—Case of a girl, aged 9½. *Top,* maxillary left central incisor knocked out. *Center,* a few months later, the left lateral incisor has been moved into the position of the lost central incisor. *Bottom,* temporary - permanent gold-acrylic central crown placed until the lateral incisor can be prepared for a porcelain jacket crown.

anterior teeth is relatively good. The two central crowns balance nicely, and the cuspid adjacent to the central incisor can be reshaped by reducing the pointed cusp to simulate the lateral incisor.

CHAPTER 7 CLASS 6

Fracture of the Root—with or without Loss of Crown Structure

Prescription for Treatment

A. Record case history (p. 25)
B. Record results of clinical examination (p. 25)
C. Diagnosis of the case; determine treatment plan
   1. *a*) Essentials for success
      (1) Fragments must be in close apposition
      (2) Fracture line not in cervical third of root
      (3) Absence of infection
      (4) General health good
      (5) Immobilization of fragments, if this is required
   b) Treatment—four methods for stabilizing teeth
      (1) Wire teeth together
      (2) Band splint
         i) Construct pinch bands for tooth in question and adjacent teeth
         ii) Solder these together in correct positions
         iii) Cement to place
         iv) Leave three to six months, as indicated

(3) Cast splint
   i) Take impression
   ii) Make investment cast
   iii) Wax splint to outline
   iv) Cast splint in gold or palladium-silver alloy
   v) Cement to place
   vi) Leave three to six months, as indicated

(4) Matrix splint
   i) Take impression
   ii) Make stone cast
   iii) Burnish 36 gauge 24 k. gold plate to outline
   iv) Conform 18 gauge round wire to outline
   v) Wax plate and wire together
   vi) Remove, invest and unite with solder
   vii) Finish and cement to place
   viii) Leave three to six months, as indicated

INCLUDED AMONG the ever-increasing number of cases of traumatized anterior teeth in young patients is a sizable group with a fracture through the root of a tooth. With the passing of time, more knowledge is being accumulated concerning these interesting cases. It is fair to state that the prognosis for these cases is highly favorable in most cases.

SOME OBSERVATIONS ON ROOT FRACTURE

Among the specific observations accumulated are many worthy of citation. It is not common to find an anterior tooth with a fracture of both the crown and

the root. Furthermore, it is rather uncommon to see a child between 7 and 10 years of age with a fracture of a root as the result of an injury. This is not to be wondered at in view of the state of eruption of the anterior teeth and the progress of root development during that period. Fracture of the root is more likely after the crown is fully erupted and the root fully developed, with the surrounding supporting structures firmly fixing the tooth in position. A further observation that is reported almost universally by those recording cases of root fracture is the high percentage of teeth which remain vital and apparently normal for many years after the accident.

The author has observed two cases similar to cases reported by Kenna[1] and one by Kronfeld[2] in which two maxillary central incisors were injured at the same time. One remained intact but the pulp became nonvital, while the other suffered a fracture of the root and its pulp retained its normal vitality. The explanation for such an occurrence is based on the fact that in the former instance the circulatory system of the pulp could not be maintained normally through the stages of inflammation because of the limitation placed on it by the hard, unyielding walls within which it was confined. In the latter instance, the space created by the root fracture provided an avenue of escape for the increased blood supply during the period of congestion and later for the possible development of a collateral connection with the circulation of the periodontal tissues, so that regeneration of the pulp was favored. In connection with the observation concerning maintenance of vitality in the tooth with a frac-

tured root, the figures given by Austin[3] are presented for consideration. Among the 40 cases of root fracture reviewed by him, no less than 31 gave evidence of a positive vitality test. Another interesting observation is that many cases have been reported in which the patient had no recollection of receiving an injury

FIG. 116.—Fractured root of right central incisor, resulting from an accident four years previously and revealed in routine radiograms made prior to orthodontic treatment.

to the tooth. Such cases are revealed only during a routine radiographic examination. The example presented in Figure 116 was discovered during a radiographic examination prior to the institution of orthodontic treatment. The patient, a boy of 12, could not remember having received a blow on the anterior teeth, nor was he ever aware of any abnormality of the right central incisor, in which the radiogram revealed fracture. Such a history is not uncommon.

Diagnosis

A fracture of the root of a tooth may occur anywhere along the length of the root from the apical to the cervical region. The review by Austin[3] of 40 cases disclosed that 90 per cent (36 cases) of the fractures

Fig. 117.—Fracture of root in the cervical third region; prognosis unfavorable.

occurred in the middle third of the root and 10 per cent (four cases) in the apical third. The fact that none was noted in the cervical third is not surprising, because teeth with fractures in the cervical third are usually lost soon after the accident.

Teeth with fractures in the cervical third usually show extreme mobility because of lack of root support; there is poor apposition of the two segments, and the line of fracture is probably open to contamination by the oral fluids through the gingival crevice. The prognosis is therefore unfavorable. An

excellent example of fracture of a root in the cervical third region is shown in Figure 117.

The line of fracture may run in a diagonal direction, but in most cases it runs horizontally or transversely across the root of the tooth. The segments may be in apposition or may be widely separated. In the latter instance, every effort should be made as soon as possible to reposition the segments by delicate manipulation of the coronal portion. Good apposition of the fractured surfaces is essential for successful treatment.

Depending on the position of the fracture and the extent to which the supporting structures have been traumatized, there may be some evidence of mobility. Vitality response from the coronal segment of the fractured tooth may not be positive immediately after the accident; therefore a negative response at this time does not indicate that the pulp is nonvital. A slow return to a state of normal vitality is commonly observed. The patient's general health will influence the process of repair and regeneration of the injured pulp tissue and must be considered when making a diagnosis. It is obvious that radiographic examination may be the only accurate method of confirming the presence or absence of a fracture of the root of a tooth.

Requisites for success.—It is apparent that the requisites for successful treatment of a tooth with a fractured root are definite. Kronfeld[4] enunciated them clearly and concisely.

"(1) The fragments must be in a position of close adaptation.

"(2) The fragments must be immobilized in this position.

"(3) Absence of infection is necessary.

"(4) The patient's general health must be such as to make reparative and regenerative processes possible."

Stabilization of Fragments

The methods commonly adopted for stabilization of the coronal portion of the fractured tooth may be discussed under four headings. They are: wiring, or

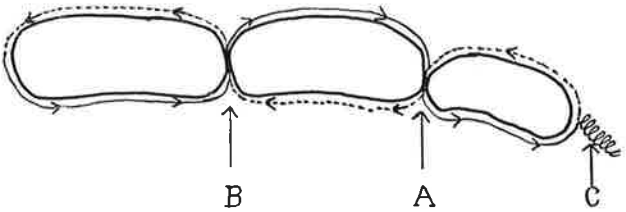


Fig. 118.—Stabilization of tooth with fractured root—wiring method.

use of a band splint, a cast splint or a matrix splint.

Wiring.—Orthodontic ligature wire, either brass, 25 gauge, or stainless steel, 30 gauge, has been used successfully. The wire is quickly and simply applied either as a temporary measure, followed later by the installation of a splint type of stabilizer, or left in position and adjusted every two or three weeks. The adaptation of the wire is shown diagrammatically in Figure 118. The broken line represents the wire being passed across the labial surface of the lateral incisor, then cervically to the contact point (*A*)

around the lingual of the fractured central incisor and incisally to the contact point (*B*), from which it passes around the labial surface of the adjacent central incisor. The continuous line represents the wire being returned in a similar manner. By being passed cervically to one contact point and incisally to the next, the wire will not slip gingivally or incisally off the teeth. The two ends of the wire may be tightened by twisting them carefully (*C*) and turning the twisted end into the embrasure away from the lips. As a temporary measure for a single tooth, this method is useful.

The band splint.—Construction of a band splint requires more time and skill but is perhaps more rigid than the wire stabilizer. Bands are constructed for the teeth adjacent to the fractured tooth. The orthodontic banding material used for making pinch bands is suitable. A third band may be constructed for the crown of the fractured tooth, and all three are united by solder. The triple band splint is then cemented to place with black copper cement. Great care must be taken to explain to the patient the need for watchfulness to see that none of the three bands becomes loose. If one band loosens, the patient should report the matter at once, for great destruction of enamel can take place inside a loose band.

As an alternative, instead of constructing a third band for the fractured tooth, two round wires, one contacting the labial and one the lingual surface of the middle third of the crown of the tooth, can be soldered firmly at each end to the bands as seen in

Figure 119. This modified band stabilizer is cemented to place. The patient must be warned of the importance of reporting a loose band and must be instructed in the need for cleanliness, especially around the two wires. There is no danger of caries occurring under

FIG. 119.—The modified band stabilizer.

the wires if extra precautions for cleanliness are taken, because the stabilizer remains in place for a comparatively short time (three to six months).

Figures 120–122 show the radiographs of a fractured central incisor of a boy of 16. The modified type of band stabilizer was used. A period of 5¼ years elapsed between the accident and the date of the last radiogram. The tooth was vital, had good color and showed no symptoms or mobility when the last examination was made.

The cast splint.—This type of stabilizer requires the greatest effort in construction. It is highly satisfactory

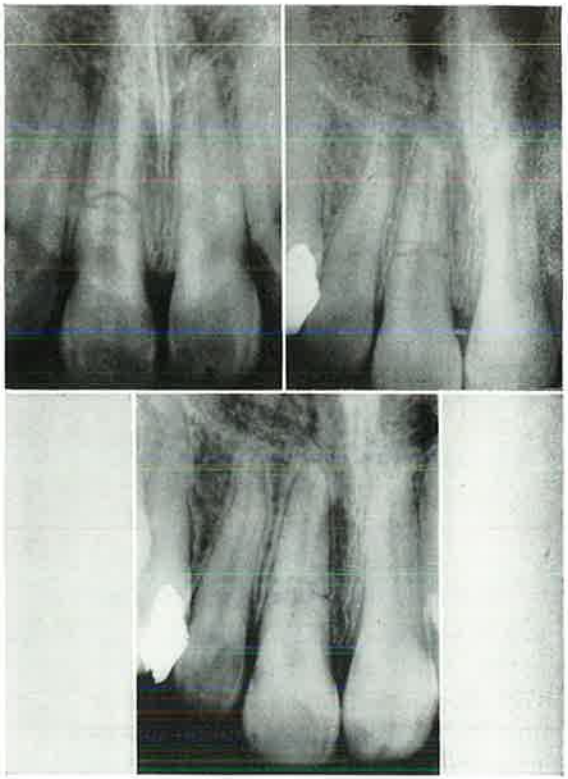


FIG. 120 *(top left)*.—Root fracture of the left central incisor of a boy of 16. January, 1939.
FIG. 121 *(top right)*.—Same case, November, 1942.
FIG. 122 *(bottom)*.—Same case, April, 1944.

especially when more than one of the adjacent teeth is required for anchorage on each side. From an accurate impression of the arch, made with one of the hydrocolloids or alginate impression materials, an investment cast is poured. The splint is waxed up directly on the investment model, then invested and cast. A double thickness of 30 gauge wax is sufficient. The incisal edges of the anterior teeth and occlusal surfaces of the posterior teeth, if they are included, are left uncovered to clear the bite. The splint is cast in a suitable hard palladium-silver, or gold alloy if desired, and polished. It is cemented to place with black copper cement.

The matrix splint.—A stabilizer similar to the cast splint may be constructed quickly and simply by the so-called matrix method. On the cast, the area which the splint is to cover is outlined, and 36 gauge 24 k. gold plate is adapted to the outline. This will have to be adapted in two sections; one for the labial and one for the lingual. A piece of 18 gauge platinized gold round wire is conformed to the same outline on the cast. The gold plate is then positioned on the cast and the round wire superimposed on it. The plate and wire are waxed together along their entire length. The assembled splint is removed and invested in a high heat soldering investment. The wire is united with the plate and the contours are filled in with 18 k. solder. The soldered splint is then dressed down and polished. This splint is a satisfactory stabilizer for a fractured root.

The length of time a stabilizer should be retained

varies with the case. The average case requires immobilization for three to six months. If the pulp in a tooth with a fractured root becomes nonvital, it is improbable that root canal therapy would be successful.

It is apparent that there is no need for stabilization in a number of cases with fracture of the root, especially when the fracture is in the apical third of the root and the fragments are in good apposition. As suggested previously, oftentimes the patient is unaware of any abnormality and does not even consult a dentist. Nevertheless the reparative process is spontaneous and effective.

Nature of the Reparative Process

The fact that a tooth with a fractured root can be maintained in an apparently healthy state provides further evidence of the amazing recuperative powers possessed by the tissues of the young person. When the pulp of the tooth responds actively to vitality tests, when the periodontal membrane is shown radiographically to be unbroken and when the shadow of the surrounding bone structure is comparable to that seen around a normal vital tooth in the same radiogram, there is no alternative but to regard the tooth as healthy and in no way endangering the systemic condition of the host. The actual process of repair of the root of the tooth has engaged the attention of many men, but few have been able to study microscopically a repaired tooth in situ. Gottlieb,[5] Boulger[6] and Kronfeld[2] have reported their histologic observations of sections of a root fracture in situ. Many other

investigators have recorded the results of histologic studies of an extracted tooth which has been repaired. A third group of investigators has studied and reported on the healing of experimental tooth fractures in animals.[7,8]

From these reports and experience with numerous clinical cases, the nature of the healing process might best be described as the envelopment of the root fragments within a protective cementum-fibrous matrix. Responses of a protective character have been alluded to frequently throughout the discussions of injuries to dental tissues in young healthy individuals. It is not considered likely that a direct regeneration or cementation of the fragments through dentin takes place, although Ottolengui[9] observed on sections of a repaired fracture that new dentin had splinted the segments of the tooth. The repair pattern may take the following course.

Immediately after injury and fracture of the root of the tooth, the natural processes accompanying inflammation envelop the line of fracture. These include the pulp tissues, periodontal tissues and root structure. Resolution takes place rapidly in the area of inflammation, unless it becomes exposed to infection, as might well be the case when the fracture line is in the cervical third of the root. Healing is most rapid when the fracture line is farthest away from the epithelial attachment. Resorption of traumatized dentin on the fragment ends accompanies the resolution of the inflammation, as if new dentin surfaces were required before the reparation process could continue. The same reaction has been observed

in the bone adjacent to the line of fracture. There follows the deposition of a layer of cementum, or what has been designated by some investigators "osteoid" or "osteodontic" tissue, to envelop the pulpal surfaces of the root fracture. The cementum-like deposition has been observed to differ from the regular cementum. "Corpuscles" similar to those seen in bone are present in the new cementum, making differentiation between where bone begins and the cementum-like deposition ends exceedingly difficult. The origin of the terms "osteoid" and "osteodontic" is therefore understandable. Regeneration of the periodontal tissues accompanies the deposition of the cementum, and a fibrous union is established. Kronfeld[2] reported that in his case, "No solid union between the two fragments of the root took place; but there was a fibrous connection that closely resembles, and is the functional equivalent of, the periodontal membrane." The cementum in some instances has been reported to have been deposited down into the root canals.

Figure 123 shows an interesting radiogram of a tooth, the root of which was fractured 20 years previously. It is still a comfortable, vital, normal tooth as far as the patient is concerned. The nature of the tissues lying between the fragments is not known, but it is probable that there is cementum covering each root fragment, with fibrous tissue similar to the periodontal membrane interposed between them. If the periodontal line is followed around each fragment, it is apparent that the line is continuous through the line of fracture. The pulp chamber and root canal in both fragments appear to be obliterated; yet vitality

responses are emitted by the pulp. This observation is not uncommon among the many cases on record.

The repair of a fracture of a tooth root and the repair of a fracture of a bone are not comparable. The cementum-like or "osteoid" tissue is deposited in a thin layer over the dentin surface of the fragments

FIG. 123.—Fracture of a maxillary right central incisor of 20 years' standing.

of the tooth root, while new bone is built rapidly and in considerable quantity around the peripheral regions of a fractured bone. The final repair of the tooth root is not always a solidly calcified union, whereas the repair of a fractured bone is eventually a continuous calcified structure.

PROGNOSIS FOR A FRACTURED TOOTH ROOT

The logical conclusion which may be drawn from the contents of this chapter is that accidental fracture

of the root of an anterior tooth does not create an uncontrollable situation. Hasty extraction of these teeth is to be condemned, unless the prognosis is unfavorable. If a fracture occurs in the cervical third of the root, if there is considerable unreducible displacement or malalinement of the fragments and if a nonvital pulp requiring root canal therapy develops, the prognosis is unfavorable. Provided none of these contraindications is present, the prognosis is extremely favorable; in fact, more favorable than if the same tooth received a similar blow without suffering a fracture of crown or root. From the practical standpoint, a fracture of the crown is more difficult to restore to normal than most root fractures.

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CHAPTER 8 CLASS 7

Displacement of Tooth—without Fracture of Crown or Root

Prescription for Treatment

A. Record case history (p. 25)
B. Record results of clinical examination (p. 25)
C. Diagnosis of the case; determine treatment plan
   1. Partial displacement, minor—class 7, division 1
   2. Partial displacement, severe—class 7, division 2
   3. Total displacement—class 7, division 3

Partial Displacement—Class 7, Division 1

i) Prescribe warm saline mouth washes
ii) Advise patient to avoid the injured tooth
iii) Warn patient of possible pulp necrosis
iv) Warn patient of need for periodic observations
v) Follow policy of "watchful waiting"
vi) If some slight amount of extrusion—later grind incisal edge by stages to restore length

Partial Displacement—Class 7, Division 2

a) Extrusion
   i) Prescribe warm saline mouth washes
   ii) Advise patient of possible pulp necrosis
   iii) Reduce displacement, possibly under anesthesia (local or general)

iv) Immobilize tooth temporarily with wiring or compound splint, while permanent splint is under construction
v) Construct permanent splint — cast or matrix method
vi) Cement splint, for three to six months
vii) Warn patient of need for periodic examinations

b) Intrusion

i) Prescribe warm saline mouth washes
ii) Advise patient of possible pulp necrosis
iii) Advise patient of need for periodic examination
iv) Follow policy of watchful waiting

Complete or Total Displacement—Class 7, Division 3

i) If seen early enough after accident, reimplant
ii) Remove pulp from pulp chamber and fill root canal
iii) Prepare root surface; scrape off hanging tissue which will slough off; render clean
iv) Immobilize tooth with splint (three to six months)
v) Prescribe warm saline mouth washes
vi) Advise patient to report any discomfort
vii) Advise patient of need for periodic examination
viii) Advise patient of need for care

IN PRECEDING CHAPTERS, attention was focused on the various forms of structural fractures suffered by anterior teeth. This chapter is devoted to the displacement of teeth. These abnormalities range in severity from partial to complete displacement. It is difficult to evaluate the disturbance created in the apical tissues following displacements, but in every type except the one which exhibits an absolute minimum of movement there must be stretching and even

laceration of periodontal fibers, apical vessels and nerves. Displacement of some bone structure also appears inevitable in cases in which extensive movement of the tooth has resulted.

General Observations on Partial Displacement

The age at which displacement occurs most frequently is influenced by the stage of development of the root of the tooth. During the formative period of the root, the crown of the tooth is top-heavy, so to speak, and a medium force applied in a critical direction may be sufficient to cause partial or more probably complete displacement. The same force applied in the same direction when the root is complete and the supporting structures are more mature might be withstood or translated into fracture of a crown or root. Thus it is not surprising to find displacement occurring soon after the crown of the tooth is erupted. Partial displacement of a tooth, the root of which is not yet completely calcified, does not often result in necrosis of the pulp. Discussion of the recuperative powers of the pulp as related to traumatic inflammation during root development is given on page 27.

Figure 124 shows the radiogram of the central incisors of a boy of 7½. The left maxillary central was elongated 1 mm. by an injury. There were much laceration and swelling of the soft tissues around the tooth. It was decided that no treatment was required because mobility was not marked, but the patient was recalled once a month for three months for observation. Figure 125 shows the development of the same central incisor 2½ years later. The pulp is normally

vital according to thermal and electrical tests, color is normal and root development is nearly complete.

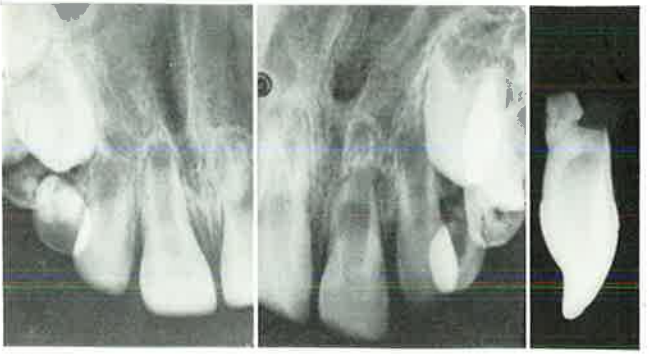
The prognosis for a partially displaced tooth is favorable when root development is not complete.

FIG. 124 *(left).*—Maxillary left central incisor of a boy of 7½ displaced slightly.
FIG. 125 *(right).*—Same case, 2½ years later.

However, in exceptional circumstances the pulp succumbs to necrosis. Figures 126 and 127 show the radiograms of maxillary right and left central incisors of a boy of 7½. The right central incisor had been displaced eight months previously. A discharging sinus over the root developed, and the vitality responses of the crown were negative. From the radiogram it would appear that the struggle for continuation of the development of the root went on despite the disturbance, but eventually necrosis of the pulp became complete. It is interesting to note that development

of the lingual aspect of the root continued after the injury while that of the labial region apparently ceased (Fig. 128).

The extracted tooth was decalcified and several sections were studied microscopically. The report



FIGS. 126 *(left)* AND 127 *(center)*.—Maxillary central incisors of a boy of 7½. The right central incisor had been displaced eight months previously; interruption of its development is evident.

FIG. 128 *(right)*.—Same case. Radiogram of the extracted right central incisor, buccolingual view.

described the conditions thus: "The pulp of the crown was degenerated to a reasonably dense fibrous structure showing what appeared to be myxomatous changes. The pulp of the root was densely infiltrated by inflammatory cells, round cells predominating. The root canal also showed a definite invasion or organization of its pulp to bone in that some sections showed the root canal almost wholly occupied by bone which appeared to have grown into the wide apical foramen. There appeared at the same time to be resorption of

the lingual side of the root proceeding from the canal space and its organization into bone." The conclusion to be drawn from this case is that a great reparative effort took place within the developing tissues of the injured tooth.

When displacement occurs in a tooth with a fully developed root, the prognosis depends on many factors. Chief among these are the amount of displacement, the patient's health and the extent of laceration of the apical tissues. The last two factors are unpredictable. Clinical observation of a number of such cases again reminds us of the almost boundless capabilities of the tissues of the young patient to repair damage.

Figure 80 (p. 132) represents a radiogram of four lower incisors of a boy of 16 which were displaced so far in the lingual direction that they were inclined at an angle of approximately 45 degrees; Figure 83 shows the same teeth nearly four years later. Only one tooth became nonvital in the meantime, but the pulp chambers in the remaining three had been almost completely obliterated. In view of the observations presented on page 190, the question might well be asked, what is the nature of the calcified substance filling the root canals in this and similar cases?

In another case, the left central incisor of a boy of 14 was displaced lingually 6–8 mm. and extruded 5–6 mm. out of its socket (Fig. 129). Three months later the same tooth (Fig. 130) was comfortable and vitality responses were definite and comparable to those of the adjacent central and lateral incisors. Fur-

ther observations of this tooth have been impossible because of the war. However, according to the parents, it is still retained by the patient (six years after the accident), it is not discolored, nor has it ever caused any discomfort.

In both of the cases just referred to (Figs. 80 and 83, and 129 and 130) the displacement was so exten-

FIG. 129 *(left)*.—Maxillary left central incisor of a boy of 14 displaced 6–8 mm. in a lingual direction.
FIG. 130 *(right)*.—Same tooth three months later.

sive that the centric bite was interfered with and the teeth were locked in their new positions between displaced bone fragments. The teeth were repositioned under a local anesthetic and immobilized with a cast metallic splint. The bone fragments were molded to place with digital pressure and apparently reunited.

Displacement of teeth is seldom complicated by fracture of the crown. The force which dislodges the tooth is absorbed in that process. The need for a radiographic examination is none the less essential, because immediately a traumatized tooth exhibits marked mobility differential diagnosis between fracture of the root and displacement is essential. Radiographic

study is the only certain means of making this distinction. Interpretation of the radiogram must be highly accurate, for it is easy to overlook a fracture

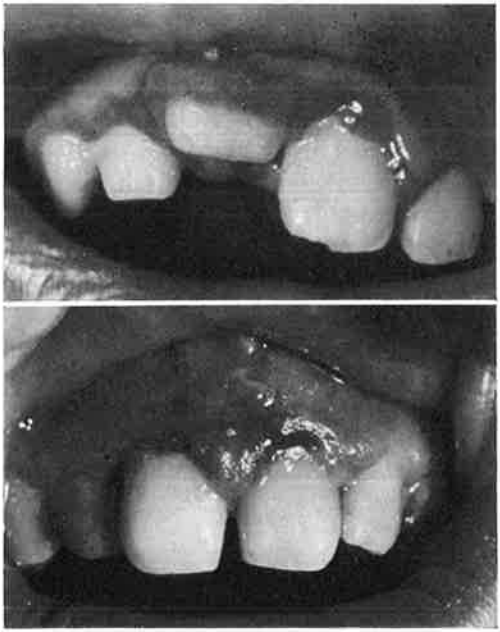


FIG. 131 *(top)*.—Displacement of maxillary right central incisor (intrusion).
FIG. 132 *(bottom)*.—Appearance of gingival tissues in a case of displacement.

line in a root. The crowns of teeth that are displaced to any extent are usually in a lingual position and the bite may be interfered with.

Displacement of permanent teeth is most often in the form of extrusion, as in the cases already men-

tioned. Occasionally displacement of the intruded variety is encountered (Fig. 131). This is the usual form of displacement of deciduous teeth, and if left alone but kept under observation, the course of re-eruption is surprisingly rapid.

Most cases of displacement are exceedingly "messy" looking when seen immediately after the accident There are considerable laceration and hemorrhage from the already swollen tissues. The dentist feels that he should do something, yet also feels quite helpless. Figure 132 illustrates an average case of mild displacement of a maxillary right central incisor of a boy of 14 seen 18 hours after the accident. One must not be overly impressed by the appearance of the tissues because in a few days the picture will have returned to normal. Prescription of warm saline mouth washes and watchful waiting is the best advice that can be given at this stage. However, if there is marked displacement, the tooth should be repositioned and immobilized at once.

When bone fragments are displaced, they should be repositioned with digital pressure under anesthesia. Seldom does one have to treat for a compound bone fracture in these cases.

Partial Displacement — Extreme Mobility but Little Displacement: Class 7, Division 1

Figure 132 shows an example of cases included in this division. Treatment consists primarily in giving advice and assurance to the parent and patient. Warm saline mouth washes are prescribed to reduce the swelling and laceration. The patient should be warned

to spare the injured tooth; in other words, to give it preferred treatment. He should be told that irrespective of what is done now, the pulp may become nonvital from shock. A radiogram should be taken and the patient impressed with the need for periodic visits to the office for observation. The first two appointments should be at intervals of one month; subsequent visits may be three to six months apart. At each visit, the tooth is examined for vitality, response to percussion, color and by transillumination, with radiographic study at less frequent intervals. Following the accident the course is well charted if this procedure is followed; if complications arise they may be dealt with summarily.

If the tooth is extruded from the socket so that its incisal edge line is 1 mm. or so below the adjacent central incisor, the deformity may be corrected by occasional judicious reduction of the enamel with suitable carborundum or diamond wheels.

Partial Displacement — Marked Displacement: Class 7, Division 2

Extrusion

Exfoliation or extrusion is the most common form of marked displacement. Figure 133 shows a case of marked displacement of the maxillary left central incisor, the radiogram of which is shown in Figure 129 (p. 196). Treatment in such a case is complicated. Besides the management already outlined, there is also need for reduction of the displacement and repositioning and immobilization of the tooth.

Reduction of the displacement and restoration of

the tooth to normal position is somewhat painful because the surrounding tissues are lacerated and swollen. Anesthesia is therefore required. When conduction anesthesia is available it is the method of choice; if it is considered unsatisfactory in the individual case, a general anesthetic may have to be used.

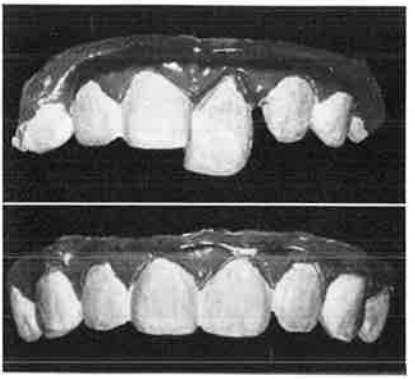


FIG. 133.—Marked displacement of left maxillary central incisor before and after treatment.

If the repositioned tooth exhibits great mobility, provision must be made at once for stabilizing it. One of the various plans of treatment outlined for stabilizing a tooth with a fractured root can be used (pp. 179 ff.). While the anesthetic is still effective, an impression is taken of the teeth after they are realined. One of the hydrocolloids or alginate impression materials is ideal for this purpose. An investment cast is poured if the splint is to be processed by the casting method, or a stone cast is poured if the matrix method

is to be used. As a temporary retainer for the realined tooth, while the splint is being constructed, wiring can be used or a temporary compound splint can be molded. When the special splint is ready for use, it is cemented to place with black copper cement. Occasionally it is necessary to use an anesthetic while placing the splint during cementation. When the four mandibular incisors are involved, the cuspids and first bicuspids on each side are used as anchor teeth. When a single tooth is involved, only the adjacent teeth need be used. The incisal edges and occlusal surfaces are left open in these splints so as to interfere as little as possible with centric and functional positions.

Details of construction of splints are presented on pages 180 ff. The splint should be left in place for three to six months, depending on the individual case; the interval must be determined by the operator. The patient is required to exercise great care of the mouth while the splint is in place.

Intrusion

Figure 131 (p. 197) illustrates the intruded type of displacement. Treatment for such a case is limited. It is well-nigh impossible to withdraw the tooth forcibly into its normal position; furthermore, it is considered inadvisable to cause further disturbance to the apical and periodontal tissues. If such a course were embarked on, it might be better to consider removing the tooth as cleanly and carefully as possible, completing root canal surgery and filling the

canal as expeditiously as possible, and then reimplanting the tooth. Reimplantation is discussed later (p. 209).

The treatment program that is recommended for intruded teeth is based on experience with a limited number of cases. Warm saline mouth washes are prescribed to aid in reduction of laceration and swelling. The patient should be warned of the possibility of the tooth or teeth involved becoming nonvital. The necessary radiograms are made and watchful waiting is observed. Repeated visits for observation at regular intervals should be arranged. In most of such cases, the teeth have moved with surprising speed back to their fully erupted state. The prognosis for maintenance of vitality in these teeth is not favorable.

Complications Following Partial Displacement

One of the commonest untoward sequelae following partial displacement of a tooth is necrosis of the pulp. If subsequent behavior of the tooth is carefully recorded from time to time and necrosis of the pulp results in nonvitality, root canal surgery can be instituted at once and the chances of success are good. On the other hand, if the pulp becomes nonvital and this is not noted, extensive apical destruction may take place before conservative methods can be undertaken. Many such teeth are subsequently lost for this reason (see Fig. 79).

A complication which is fortunately rather uncommon is shown in Figure 134. The characteristics are well illustrated by the history. The patient, a girl of

7, fell and injured the partially erupted maxillary central incisors. The alveolar tissue surrounding these erupting teeth was badly lacerated. Figure 134 was taken six months after the accident. The patient

FIG. 134 *(top)*.—Giant cell epulis, a probable complication after injury.

FIG. 135 *(bottom)*.—Same case, eight years after removal of the giant cell epulis.

came for treatment not because of pain or any discomfort but because the inflamed mass of tissue between the two incisors was enlarging fairly rapidly and, as it did so, the diastema between the

teeth was increasing in size. Furthermore, the highly vascular granulation-like mass of tissue bled spontaneously at night, leaving a gory mess on the pillow by morning. The condition is a rather typical giant cell epulis. It is characterized microscopically by an epithelial surface layer in a state of ulceration, with a base showing chronic inflammation extending to tissue composed of immature fibrous cells of the osteoclastic type. Treatment consists of radical excision of the growth to its deepest ramifications. The prognosis is favorable, and recurrence is unlikely if removal is complete (see Fig. 135).

A complication which is commonly misinterpreted is the median line maxillary cyst (Fig. 136). One of the difficulties in the diagnosis of such a case is the resemblance of the small median line cyst and the radicular cyst, both radiographically and symptomatically. In the case illustrated, the maxillary left central incisor was bumped on the head of a playmate in 1930, when the patient was 8 years old. A blow of greater intensity loosened the same tooth six years later, but it soon ceased to cause discomfort, although it never was as firm as the adjacent central incisor. This information was supplied by the father, who is a dentist. Early in 1940, when the patient was 18 years of age, swelling began to appear in the palatal tissue adjacent to the maxillary left central incisor. The symptoms accompanying this swelling were severe, being similar to those of an acute abscess. The palatal swelling was lanced and drained. On the assumption that the maxillary left central incisor was

the cause of the disturbance, it was decided to gain access to the pulp chamber through the lingual surface of the tooth. When the drill entered the dentin, however, the tooth reacted as if it were vital. Further manipulation was postponed. Vitality tests of all six maxillary anterior teeth gave convincing proof that

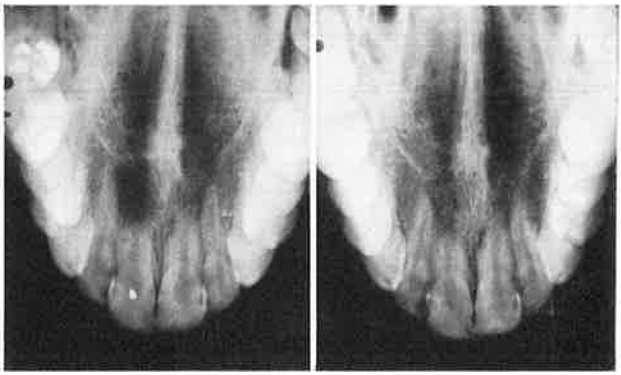


FIG. 136 *(left).*—Median line maxillary cyst over a vital left central incisor in a patient of 18. Injuries to the anterior teeth were suffered at ages 8 and 14.
FIG. 137 *(right).*—Same case, four years after removal of the cyst. The four maxillary anterior teeth are vital and normal.

the pulps in each were normally vital. The inflammation subsided in a few days and the cyst was removed from the palatal surface. Figure 137 shows the same case four years later.

The median line cyst supposedly arises from activation of epithelial remnants which remain in the suture line of the premaxillary union. One known exciting cause is injury to the maxillary central incisors. Fortunately, the condition is not common.

Another complication of uncertain origin is illustrated in Figure 138. The history of this patient, a man of 27, is interesting. Seven years before, he received a blow on the maxillary central incisors while playing hockey. The right central incisor became

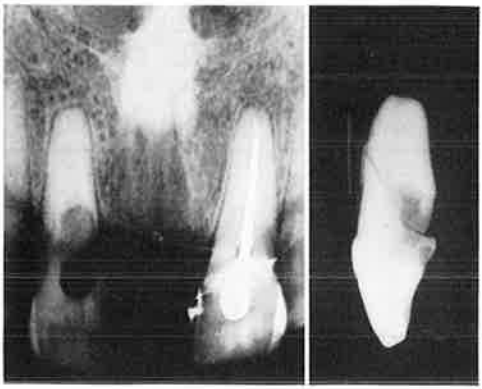


FIG. 138 *(left)*.—Probable perforating hyperplasia of the pulp of the maxillary left central incisor following injury to both central incisors seven years previously.
FIG. 139 *(right)*.—Same case. Extracted left central incisor, showing change of the root on the lingual side of the canal.

nonvital, and root therapy had been performed recently on this tooth. There were no signs or symptoms to indicate that this tooth was nonvital (see Chap. 5). The left maxillary central responded to vitality tests and was in every way a normal tooth. Careful examination of the crown revealed an opening into the pulp chamber on the lingual side at a point 1 mm. above the gingival tissue line and extend-

ing 1 mm. below the tissue line. Filling this opening like a plug from within was a mass of vascular, slightly sensitive tissue which was connected with the pulp tissue and apparently had no connection with the gingival tissue. It is supposed that this condition, which is also revealed as an extensive area of absorption within the middle third of the tooth, is an example of perforating hyperplasia of the pulp, or "pink spot" described by Mummery.[1,2] During extraction of the tooth it fractured easily because of structural weakness. Fracture would undoubtedly have occurred soon in the mouth, because pathologic fracture is the inevitable result in these cases.

The two extracted segments of the tooth were placed in apposition and a radiogram was made (Fig. 139). It is interesting to note that the resorption process within the tooth had all occurred on the lingual side of the root canal. Both fragments were then decalcified and serial sections were studied. The report of this study follows.

Root fragment. The break had occurred just below the gingival line, and normal cementum enveloped the dentin. The dentin appeared to be undergoing degeneration in that its stain affinity varied in intensity. The tubular markings were, however, definite in all places, and the assumed degeneration may have been an artefact.

Crown fragment. The dentin of the crown appeared to be normal except at a spot just below the gingival line, where there had been an area of excavation extending to the pulp chamber. The margin of this cavity on the coronal side showed changes in the

dentin similar to, but not identical with, ordinary caries. The space which was presumed to be the fracture through which the pulp had been extruded seven years before was occupied by dense fibrous tissue which showed evidence of chronic inflammation by moderate round cell infiltration but was covered by hyperplastic epithelium. The pulp chamber as well as the root canal was completely occupied by bone of cancellous structure, though it was more dense than in the root canal.

The suggestion that a fracture of the root occurred at the time of the accident seven years previously is to be noted. However, several factors rather disprove this as a probability. If a fracture occurred in this region, it is almost certain that the coronal fragment would have been extremely mobile. The patient says that this was not the case, nor was it necessary to splint the tooth to immobilize it. Then, too, the labio-lingual radiogram (Fig. 139) reveals that only the tooth structure lingual to the canal was involved. The evidence is strongly against the assumption that the root was fractured, and the original view is adhered to, viz., that this is a case of perforating hyperplasia of the pulp excited by traumatic injury.

Total or Complete Displacement—Class 7, Division 3

The circumstances which attend the complete displacement of an anterior tooth by trauma are truly an enigma. How a simple blow on the labial face of the crown can so cleanly and completely dislodge the tooth remains unexplained. Often no other tooth is

involved by the dislodging force. The author has seen several cases of complete displacement of one central incisor by a blow from a fist. This form of accident may occur at any age, but if it occurs before the root of the tooth is fully developed, the chances of success with the treatment to be suggested are not good.

Treatment.—The only form of conservative treatment which is available for these cases is that of reimplanting the dislodged tooth. It is essential that the patient be seen within a few minutes after the accident, or at least before the clot becomes densely organized in the socket. The tooth must be in one piece and preferably have been placed in salt solution by the patient or the parent for transportation to the dentist. The pulp must be removed at once and the canal carefully reamed to the convenient diameter, then completely filled with the root canal filling material of choice. Recommendations for the preparation of the external surface of the root have differed greatly. One suggestion is that the root surface be sterilized in pure phenol; another is that the root be washed clean in normal saline solution and nothing further done; still another is that the root surface be carefully scraped free of all tissue attached to it and left clean and smooth, as if well polished, so that it will be tolerated by the tissue in the socket.

The tooth is replaced in the socket and provision made for its stabilization. A splint of the cast or matrix type may be made; while this is being done, the tooth may be immobilized by the wiring method or a temporary compound splint. The splint is cemented to place and left in position for three to six months.

Prognosis.—The prognosis for a reimplanted tooth is favorable for a brief span. If the tooth renders service for 10 years after reimplantation, the operation must be considered to have been eminently successful. The average life of reimplanted teeth is probably seven to 10 years.

Figure 140 shows the radiogram of a maxillary left

FIG. 140.—Reimplanted maxillary left central incisor.

central incisor which was reimplanted seven years before. Resorption of the root apex is evident, with the root canal filling projecting beyond the root.

Complications and sequelae.—The usual reason for eventual failure of reimplanted teeth is resorption of the root, which leaves the root canal filling projecting beyond the end of the root into the adjacent bone. In some instances the root seems to disappear or to be replaced by bone.

It is essential that the root canal be cleaned out

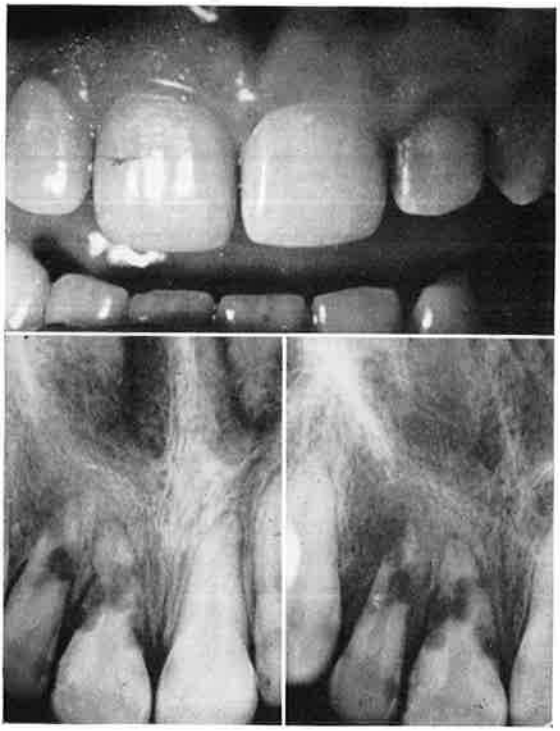


FIG. 141 *(top)*.—Reimplanted maxillary left lateral and central incisors.

FIGS. 142 AND 143 *(bottom)*.—Radiograms of same incisors a few months after reimplantation.

and a good root canal filling be placed before the tooth is reimplanted. If this procedure is not followed, resorption of the root will commence after a comparatively short time. Figure 141 is an interesting example. The left lateral and central incisors had been reimplanted after an accident four months before this photograph was taken. The appearance of the surrounding gingival tissues was excellent. No periodontal pockets were found at any point around these teeth. The color of the lateral incisor was very slightly off. There was no response to vitality tests. The radiograms of these teeth taken four months after reimplantation are shown in Figures 142 and 143. Extensive root resorption is already far advanced. Therefore it is strongly recommended that if reimplantation of displaced teeth is to be resorted to, the root canal of the tooth must be completely reamed out and filled.

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CHAPTER 9 CLASS 8

Fracture of the Crown en Masse and Its Replacement

Prescription for Treatment

A. Record case history (p. 25)
B. Record results of clinical examination (p. 25)
C. Diagnosis of the case; determine treatment plan
   1. *a*) Essentials for success
      (1) Good root canal therapy
      (2) Preservation of crown in moist condition
      (3) Prevention of gingival tissues extending over root stump
      (4) Accurate cementation of the crown
   b) Treatment
      (1) Anesthetize tooth with local anesthetic
      (2) Remove semiattached crown by severing lingual tissue fibers holding it in place
      (3) Preserve crown in normal saline solution immediately it is removed
      (4) Remove pulp from root canal
      (5) Treat root and place root canal filling (see Chap. 5, class 4, division 1)
      (6) Remove pulp tissue from coronal portion of pulp chamber of detached crown

(7) Fit post into previously filled root canal and provide for its extension to fit into pulp chamber of crown when crown is replaced on root
(8) Cement post into crown and root at one operation
(9) Prognosis is good provided all stages from root canal therapy to the end have been completed satisfactorily

General Considerations

The cases included in this group present remarkably similar characteristics. The crown of the tooth is fractured along an oblique line in the labiolingual direction. On the labial surface the line of fracture is at or near the gingival crevice line, while on the lingual side it is 1–2 mm. beneath the attachment of the gingival tissues. The crown portion of a typical case is shown in Figure 144. Attachment of the gingival tissues to the lingual surface of the crown fragment assures retention of the crown in the mouth. This is propitious inasmuch as the crown is maintained in its natural environment and is not permitted to become dried out, if it is kept at all, with resultant deleterious portion by the accident, it is left usually to become dried out, if it is kept at all, with resultant deleterious effect on the structure of the enamel and dentin. Furthermore, the extensively involved pulp is protected against direct exposure when the crown is retained in position by the gingival tissues.

In the past, treatment of these cases was influenced by the many difficulties accompanying construction of

a successful restoration, the lingual margin of which was below the line of normal attachment of the gingival tissues. It is extremely difficult to take an impression and construct a restoration which will be

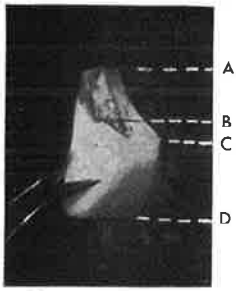

FIG. 144 *(left).*—Complete fracture of the crown, showing oblique line of cleavage in the labiolingual direction. *A*, lingual margin; *B*, pulp tissue; *C*, labial margin; *D*, incisal edge. FIG. 145 *(right).*—Complete fractures of crowns of maxillary right lateral and central incisors.

tolerated by the overlying tissues. To overcome these and other difficulties which arise, it is suggested that use be made of the natural crown which was fractured off, at least as a temporary restoration. If the line of fracture is clean, the "margin" will be well-nigh perfect. If the natural shade of the crown can be maintained, it should be in pleasing harmony with the adjacent teeth. If suitable retention can be arranged, it should resist the force of mastication during normal function.

After careful clinical examination of the tooth and surrounding supporting structures, history and clinical observations are recorded and radiograms of the tooth are taken from at least two different positions mesiodistally. A single radiogram sometimes does not reveal the presence of a second line of fracture in the root. The radiograms are used also to disclose the stage of development of the root apex and other important information about the root; this information must be accurate.

Because of the extent of involvement of the coronal portion of the pulp tissue and because of the treatment plan, root canal therapy is necessary. The factors of age, health and the number of nonvital teeth already present in the mouth must be considered. It is probable that the resistance of the periapical tissues has been interfered with as the result of trauma, and therefore extreme care must be exercised during the stage of root canal thrapy. The final result of the crown replacement is dependent on successful removal of the pulp tissue and the placement of an aseptic root canal filling.

Treatment Outline

At the earliest possible appointment, a local anesthetic is given for removing the crown and the pulp from the root. The gingival tissue adhering to the attachment on the lingual aspect of the crown is carefully severed with a lancet and the crown removed. A bath of normal saline solution, not water, should be available into which the crown is placed on removal from the mouth. The gingival tissue fibers on the

crown are denuded from their attachment, leaving a polished smooth surface in this region. Before the crown is placed in its saline bath, it is carefully scrutinized for possible comminuted pieces of enamel or dentin which might interfere with its replacement later. The crown is tried back in the mouth on its root stump to ascertain definitely at this stage whether or not it will lend itself to replacement. If it does not, now is the time to find out—not after valuable time has been spent performing root canal therapy. The saline bath should be changed from time to time to maintain a normal saline medium during the interval required to complete root canal therapy.

Before the pulp tissue is removed from the root canal, bleeding from the lingual tissues must be controlled with a suitable styptic. It is seldom possible to place the rubber dam on the remaining root stump because it is so short. Similarly, the adaptation of a copper band to aid application of the rubber dam is extremely difficult.

The contents of the root canal are removed and the canal is filled at a subsequent visit, using the best possible methods of asepsis under the circumstances.

The procedure of sealing a dressing in the root canal also involves the problem of packing the gingival tissues back so that they cannot encroach on the root stump. Two suggestions are offered. The first is simpler but not ideal from the esthetic standpoint. A stainless steel post 6 or 7 mm. long of suitable gauge is cut to fit the opening of the canal. The post is sealed into the canal with temporary cement and left projecting 3–4 mm. beyond the end of the root stump. Two

or three small sections of base plate gutta-percha the size and shape of the root stump are cut. A hole is made with a rubber dam punch in the center of each, large enough to slip them over the post extending beyond the root stump. One at a time the sections of gutta-percha are warmed and packed to place over the post. Thus the tissue surrounding the root end can be maintained in normal relationship to the root. At the same time the absorbent point with the drug on it is sealed into the canal. At the next sitting, the gutta-percha is easily removed and with a small pair of flat beaked pliers the post is rotated out of its position.

The second suggestion for sealing in the dressing and preventing the tissues from spreading out over the root end fulfils the esthetic requirements. A section of posting material is chosen, as mentioned for the first method, except that it might be a trifle longer in this case. The end of the post which is to extend beyond the root stump is flattened so that its mesiodistal diameter is at least twice that of the buccolingual. The post is cemented into the root canal and the flattened end beyond the root is left as long as the bite will permit. A celluloid crown form is contoured to fit the gingival outline of the root stump and at the same time conform to the biting positions. The appropriate shade of silicate cement is chosen. The labial face inside the celluloid crown form is veneered with the silicate cement and placed in position on the root so that when the cement is hard it will not impinge on the post already cemented in the root canal. When the silicate cement is set, the crown form

is filled with an oxyphosphate cement and seated on the root stump over the post. At the next appointment the temporary crown is removed with little difficulty by a rotary motion. It can be used over again as often as required.

Preparation of the crown.—After the first appointment, the crown, which is now in the saline bath, must be cleaned of all adhering pulp tissue. The coronal portion of the pulp chamber of the anterior tooth of the young patient is flattened mesiodistally and must be preserved in that shape. Every particle of pulp tissue must be removed from the pulp chamber to make sure that there will be no subsequent discoloration of the crown. The great difficulty experienced in tracing out the fine extensions of the horns of the pulp, even when the crown is in one's hand and access is perfect, makes one more appreciative of the fact that it is unlikely that one ever removes this tissue entirely from the crown when it is in the mouth.[1] On the other hand, no more sound dentin should be removed from the walls of the pulp chamber than is absolutely necessary, or the natural background for the enamel will be lost and the crown may appear a shade or two lighter than it should.

At subsequent appointments, completion of the root canal filling is accomplished. Any evidence of trauma in the periodontal tissues must disappear before the crown is replaced, or even before the root canal is filled.

After completion of the filling of the root canal, the crown is attached to the root and retained with the aid of a well fitted post (Fig. 146). A 16 gauge

platinized gold post of suitable length is selected; it should be long enough to extend into the root at least 8–10 mm. and into the coronal portion of the pulp chamber as far as possible. To this post is soldered a second piece (Fig. 146, *B*) which will fit

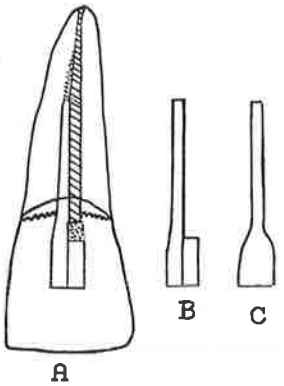

FIG. 146.—Post fitted into crown and root.

into the coronal portion of the pulp chamber. Instead of soldering this piece in place, the original post may be cut too long and the extra length may be bent back on itself to form the broad flat end required for the coronal portion of the pulp chamber. The broad end of the prepared post should fit snugly into the coronal pulp chamber (Fig. 146, *A*) to prevent any tendency for the crown to rotate on the post. By a series of trials and adjustments, made where necessary, the crown and root can finally be alined with the post in position.

Cementing the crown to the root.—Attachment of the crown to the post and both to the root is accom-

plished in one operation. This permits of adjustments before the cement sets and insures perfect alinement of the crown on the root. Figure 147 shows models before and after replacement of a lateral crown of a boy of 16. The line of fracture on the labial surface

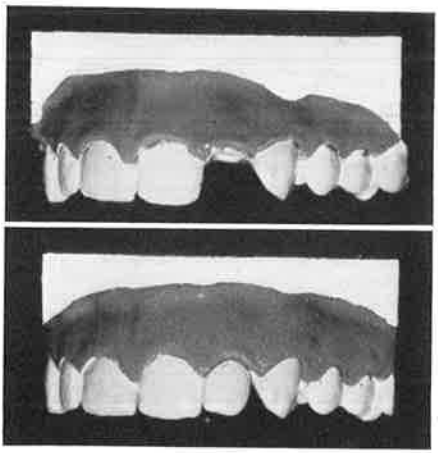

FIG. 147.—Before and after replacement of the maxillary left lateral incisor crown. (See also Fig. 148.)

was 1 mm. beyond the gingival line. When the boy came to the office, the crown was in place in the mouth, hanging by the lingual tissue. Treatment followed the outline just presented. Figure 148 shows the crown in place in the mouth six months after completion; there is no discoloration of the crown but slight darkening of the root portion which was exposed on the labial side.

Another example of successful replacement of a

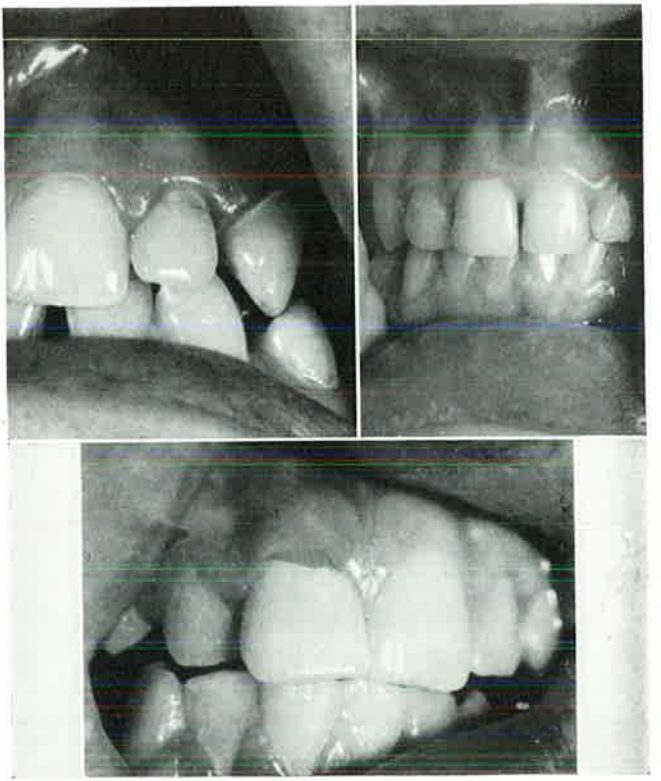

FIG. 148 *(top left)*.—Same case as that in Figure 147.
FIGS 149 *(top right)* AND 150 *(bottom)*.—Replacement of maxillary right central crown.

central crown is shown in Figure 149. The labial line of fracture was not more than 0.5 mm. beyond the gingival tissues. The lingual line was 1.5 mm. beneath the periodontal tissue attachment, and the crown was held in place by this attachment.

A similar example is shown in Figure 150. The retention of color of the crown portion of the tooth is very convincing.

Prognosis

The prognosis for these cases seems good. Because the crowns are nonvital, they are brittle and might develop structural line cracks. However, natural teeth are used on artificial denture bases quite successfully as long as they are kept moist. With the attachment of the periodontal tissues stripped from the lingual portion of the crown, it is likely that a pocket might develop in that region. Clinical experience in this respect is good. As far as color change is concerned, no darkening has been observed in these cases after several years.

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CHAPTER 10 CLASS 9

Traumatic Injuries to Deciduous Teeth

Prescription for Treatment

A. Record case history (p. 25)
B. Record results of clinical examination (p. 25)
C. Diagnosis of the case; determine treatment plan
   1. Fractures of deciduous teeth—class 9, division 1
   2. Displacement of deciduous teeth—class 9, division 2

Fractures of Deciduous Teeth—Class 9, Division 1

a) Crown—usually pulp exposure
   i) Pulpotomy, root therapy or extraction
   ii) If pulpotomy or root therapy, temporary restoration of cement only

b) Root fracture
   i) If favorable, see chapters on root fractures
   ii) Generally unfavorable, extract
   iii) No replacement needed

Displacement of Deciduous Teeth—Class 9, Division 2

a) Partial displacement—intrusion
   i) Warm saline mouth washes
   ii) Watchful waiting

b) Total displacement
   i) No replacement required

General Observations

About the time the young child begins to walk and is uncertain on his feet, traumatic injury to the deciduous anterior teeth becomes a possibility. It is amazing how many times a child will fall or bump into something, hurting the lips and teeth, with the incident soon forgotten. Occasionally, however, the trauma reaches such proportions in both magnitude and direction as to cause fracture or displacement. A wide variety of causes may be listed, but most of them are associated with the instability during this learning period. Seldom are the deciduous anterior teeth without lip coverage, so that this predisposing factor referred to with the permanent anteriors is negative. The mandibular deciduous incisors are seldom involved.

The alveolar bone and tissues supporting the maxillary deciduous incisors are not mature and therefore in a fluid state, so that the commonest manifestation of trauma to these teeth is complete displacement of the intrusion type. When a fracture of the crown does occur, the pulp is generally exposed, owing to the shape of the tooth and the extensiveness of the pulp chamber; with fracture of the root, there is likely to be considerable displacement. A simple blow on a deciduous tooth without any of these complications is withstood readily by the pulps of these young teeth. Necrosis of the pulp is usually shown by discoloration of the crown. Knowledge of the stage of development and normal resorption of the deciduous anteriors is helpful when deciding on a treatment plan. Figure

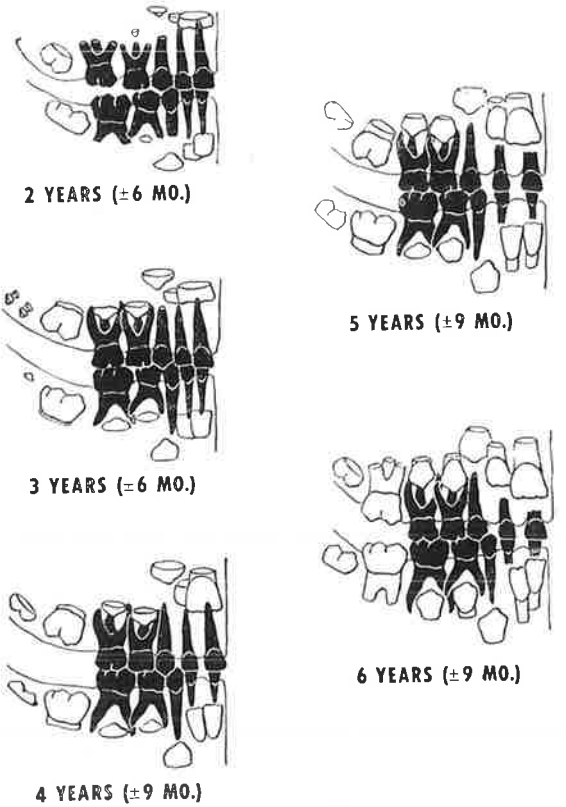

FIG. 151.—Development and eruption of the teeth from ages 2 to 6. (Courtesy of Dr. I. Schour and Dr. M. Massler.)

151 shows the deciduous teeth at the ages when this type of traumatic injury is most likely to take place.

Treatment of injuries to the anterior deciduous teeth may be considered under two headings. The first includes all forms of fractures of the crown and root, and the second, all forms of displacement. Treatment of the deciduous teeth differs from that suggested for the permanent teeth because of certain factors peculiar to the circumstances. For instance, sometimes it is difficult to obtain co-operation from a child under 3; a restoration for the lost portion of the crown structure is unnecessary at age 5 because the root is absorbing normally and will soon be lost, and replacement of a completely displaced central at age 4 is unnecessary because the normal growth developments and the erupting central incisor will maintain the space. However, it may be advisable in some cases to arrange for the construction of a simple partial denture replacement for three reasons: (1) prevention of the development of speech defects; (2) prevention of tongue thrusting habits; (3) esthetics.

Fracture of Deciduous Teeth: Class 9, Division 1

Fractured crown.—A fracture of a small portion of enamel of a deciduous incisor is quite uncommon. Perhaps the explanation for this is given partly in the short, stubby shape of the crown and the thinness of the enamel. A crown fracture is usually of the class 3 type, with the pulp extensively exposed. Pulp capping has not proved very satisfactory for these cases in the deciduous dentition. Pulpotomy is excellent, if co-operation of the patient can be obtained. Root therapy

can also be performed if all other considerations justify the time and effort required for success. Among the factors to be considered is the knowledge that the need for space maintenance for an incisor of the deciduous dentition is not as acute as it is for the permanent tooth. If a large portion of the crown is missing and successful pulpotomy or root therapy has previously

FIG. 152.—Fractured maxillary deciduous central incisors in a child of 3.

been accomplished, provision of a temporary restoration may be difficult. The attitude may be adopted that if the root is healthy and a crown restoration is difficult, leave the root stump protected only by cement, retained around a short post in the opening of the canal.

Fractured root.—Most fractures involving deciduous tooth structure are located in the roots, especially in the cervical third. There is the accompanying characteristic of marked displacement of the coronal frag-

ment. Figure 152 shows a radiogram of two fractured deciduous central incisors of a boy of 3. There is no choice of treatment except extraction in this case. If the two fragments remain in good apposition and the patient is co-operative, the fragments might be successfully immobilized for three to six months by the wiring method or the use of a splint. Such a combination is not frequently found, but it is believed that results can be obtained which would be similar to those experienced in the permanent dentition.

Displacement of Deciduous Teeth: Class 9, Division 2

Partial Displacement

This group includes both extruded and intruded teeth. In the permanent dentition, extrusion is more common; the situation is reversed in the deciduous dentition.

Intrusion type.—The commonest form of displacement observed in the deciduous arch is characterized by the partial or complete disappearance of one or more incisors into the alveolar structures. This has been referred to as intrusion. There is little that can be done in the way of treatment. The parent may be instructed to redouble the home efforts to keep the mouth and particularly the involved area clean by use of warm saline mouth washes or by bathing the area with a cotton swab dipped in warm saline or boric acid. The parent should also be impressed by the need for periodic observation of the tooth and importance of reporting any symptoms of discomfort to the dentist. The probability of the pulp under-

going necrosis should be explained, as well as the possibility that if the tooth returns to position it may discolor and a "gumboil" eventually develop over it. Sometimes the labial plate of bone is fractured and may act as a sequestrum. If the decision is made to

FIG. 153.—Maxillary deciduous left central incisor, returned to normal position after displacement (intrusion). Pulp became necrotic and apical area developed.

remove the involved tooth, test the bony socket and remove any loose fragments.

These intruded teeth will probably re-erupt in a relatively short time, but ultimate necrosis of the pulp seems to be almost inevitable. Figure 153 shows a radiogram of the deciduous central incisors of a girl of 4½, made upon the development of a discharging sinus over the root apex of the left central incisor 2½ years after the tooth was displaced (intrusion). At the time of injury it was impossible to obtain a radiogram

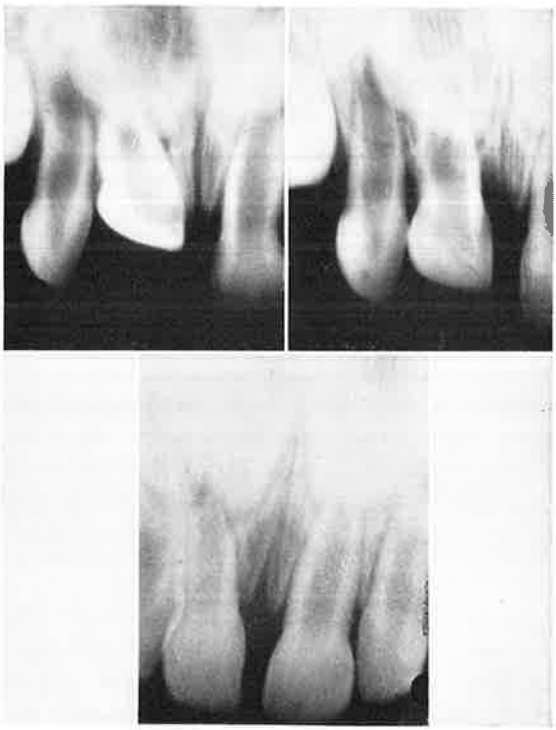

FIG. 154.—Displaced maxillary deciduous left central incisor of a child of 2. *Top left,* immediately after the accident. *Top right,* two weeks later. *Bottom,* nine months later. (Courtesy of Dr. S. A. MacGregor.)

because the patient was not co-operative. The crown of the tooth was buried so that the incisal edge was showing in a crypt in the maxillary ridge. Within six months of the injury, the tooth was in the arch in normal position and the color was good, but it was impossible to record vitality tests. A similar case is illustrated in Figure 154. Extraction of the tooth is recommended when it ceases to be healthy and becomes a possible source of infection to the host. Thus the policy of watchful waiting is recommended for these cases of intrusion. Sharenson[1] has reported observations on the management of such a case.

Extrusion type.—The partial displacement of the extrusion type is not common except when caused by a fractured root. Treatment advised for the same type of case in the permanent dentition is satisfactory.

Complete Displacement

As stated previously, total loss of a deciduous tooth as the result of trauma is one of the two commonest manifestations of traumatic injury suffered by the deciduous dentition.

In the discussion of treatment for total displacement in the permanent dentition, reimplantation was described. In the deciduous dentition, a program of treatment based on reimplantation may not be practical. Furthermore, the necessity for retention of the deciduous tooth, while desirable, is not as great as in the case of the permanent tooth. Accepting the fact that a totally displaced deciduous incisor is a lost

tooth, one is faced with the need for space maintenance. It is generally agreed that because of the nature of the growth and development in the anterior region, a fixed type of space-maintainer not only is unnecessary but may be detrimental because of the limitation it sets to normal expansion in this region. This is especially true in the maxilla.

Complications Involving the Permanent Teeth

The possibility of injury to the permanent tooth germ or developing tooth as a complication of traumatic injury to the deciduous teeth is cause for concern. The close proximity of the roots of the absorbing deciduous tooth and the developing permanent tooth renders forceful displacement of the former a direct disturbance to the latter. Several manifestations of these disturbances can be readily illustrated.

1. *Hypoplasia of the enamel.*—It is thought that a disturbance of the enamel organ during the formation of the crown of the permanent tooth accounts for the hypoplastic enamel on the incisal edge of the left lateral incisor shown in Figure 155. There was a history of severe injury to the deciduous anterior teeth at age 1½ which resulted in total displacement of some of these teeth and partial displacement (intrusion) of the others. Figure 156 shows radiograms before and after placement of a porcelain jacket crown. This type of restoration is advised when conditions make it safe to prepare for it.

2. *Dilaceration.*—Another manifestation of injury to

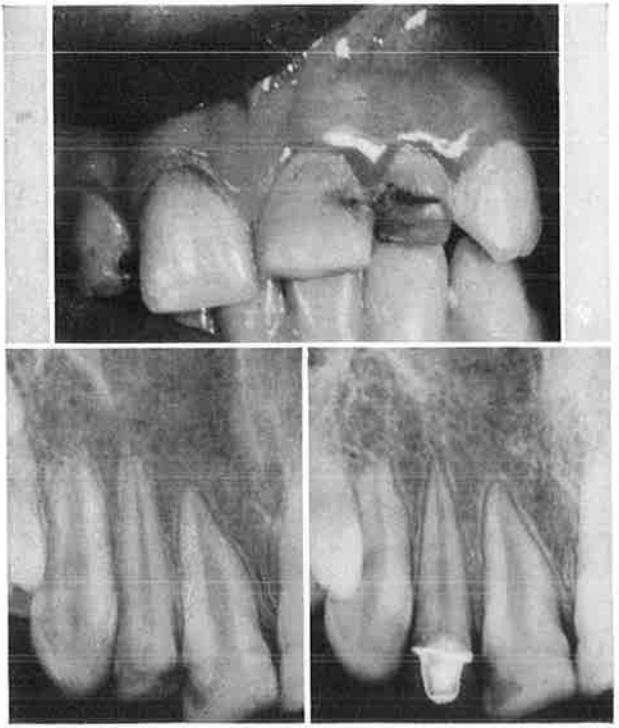

FIG. 155 *(top)*.—Hypoplasia of enamel of the permanent teeth caused by displacement of deciduous teeth.
FIG. 156 *(bottom)*.—Same case, before and after placement of porcelain jacket crown on the lateral incisor.

the developing tooth of the permanent dentition takes the form of malalinement of the long axis of the tooth. Depending on the age or stage of development of the tooth at the time of the disturbance, the defect will appear at the junction of the crown and root (Fig. 157, left) or within the root of the tooth (Fig. 157, right).

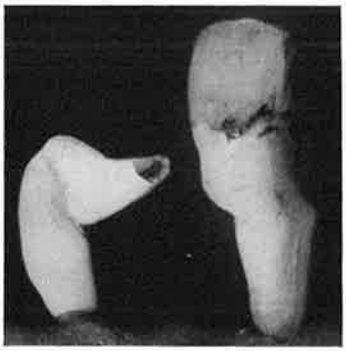

FIG. 157.—Examples of dilaceration probably caused by injury and displacement of deciduous teeth.

The history of the condition shown in Figure 157 (left) is interesting. This tooth was removed from a girl of 16 because the crown of the tooth was erupting through the upper lip. According to the parent, at the age of 2 she fell, dislodging completely the maxillary left deciduous incisor. The deciduous lateral incisor was loosened. When normal eruption of the maxillary right permanent central and lateral incisors took place, those on the left did not appear, nor was there any evidence of their erupting normally up to

the time of examination at age 16. A hard mass in the soft tissue of the buccal fold was presumed to be the crown of the central incisor. Radiograms of the left central incisor in place and after extraction are shown in Figures 158 and 159. What appeared to be a fracture at the junction of the crown and root was an

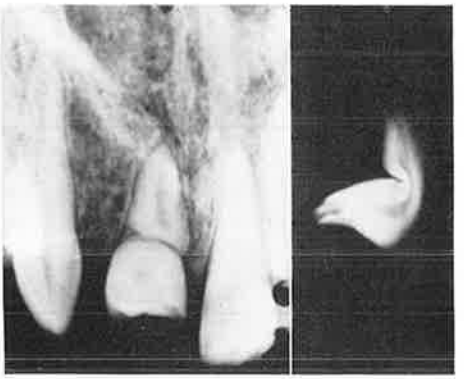

FIG. 158 *(left)*.—Maxillary left central incisor in place. An apparent fracture line at the junction of crown and root was explained after removal of the tooth (see Fig. 159).
FIG. 159 *(right)*.—Same case. Dilaceration caused by displacement of the corresponding deciduous tooth.

illusion caused by a constriction at that point. The crown is at right angles to the root. For this reason it appeared to be erupting high in the buccal fold and toward the soft tissue of the upper lip.

A similar example is shown in Figure 160. The patient, a girl, was 13 when the radiogram was made. The only information which could be obtained from the parents was very indefinite. The girl had fallen

when 2 years of age and traumatized the deciduous teeth. The crowns of the maxillary left lateral and central incisors were hypoplastic, and the radiograms show evidence of dilaceration of both teeth. The right

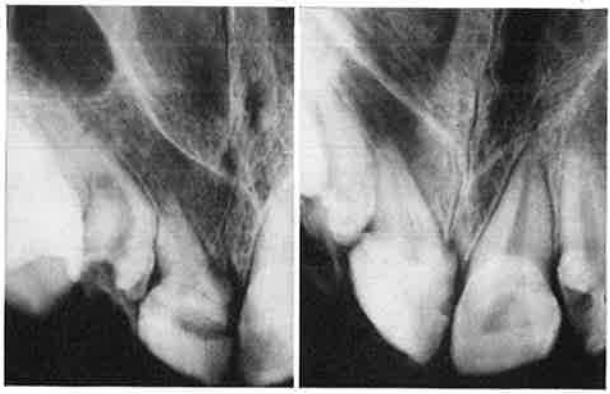

FIG. 160.—Maxillary left lateral and left central incisors of a girl of 13, with history of accident to unspecified deciduous anterior teeth at about 2 years of age. Possible dilaceration of maxillary left lateral and central incisors. Note normal right central incisor.

central and lateral incisors have a normal appearance.

Another example appears in Figure 161.

3. *Cessation of root formation.*—The nature of the disturbance to the permanent tooth may be manifested by a cessation of development of the root. Whether the tooth remains vital or becomes nonvital it is difficult to determine. The eruption process appears to be interfered with in some of these cases and not in others. Figure 162 shows the radiogram of the maxil-

lary right central incisor of a boy of 9; the root development seems to have ceased. The tooth has erupted irregularly. According to the parents, the deciduous teeth were injured, but the details of the accident are vague.

Figure 163 shows the radiogram of the maxillary incisors of a girl of 8. Between 1 and 1½, she fell and

FIG. 161.—Probable dilaceration of maxillary right central incisor of a patient of 6, with history of injury to the deciduous anterior teeth.

partially displaced (probably intrusion) the right deciduous lateral and central incisors. The right maxillary central incisor of the second dentition has not erupted, and development appears to be lagging in comparison with that of the left central. The right lateral incisor, which is not yet erupted, appears to be hypoplastic, and a hypoplastic line appears across the middle third of the right central crown.

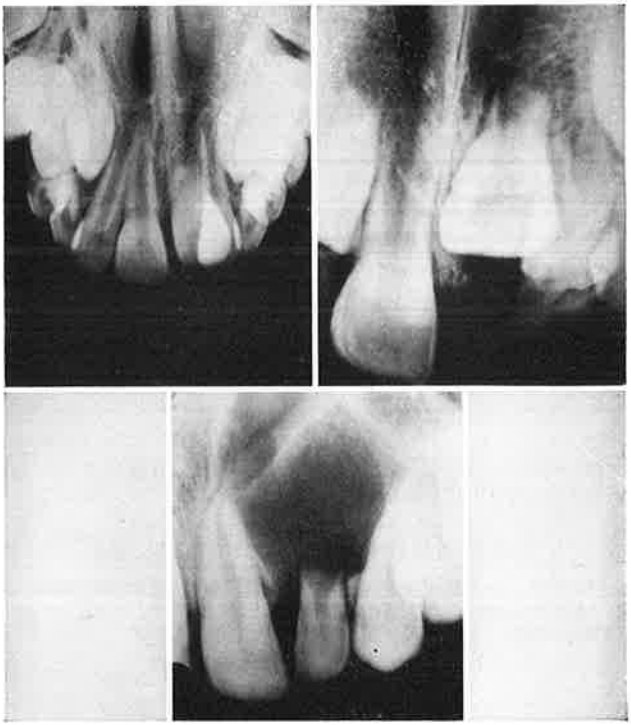

FIG. 162 *(top left).*—Interference with root development of maxillary right central incisor, probably due to injury to the deciduous teeth.

FIG. 163 *(top right).*—Probable hypoplasia of enamel and interference with root formation of the maxillary right lateral and central incisors in a patient with history of displacement of the corresponding deciduous teeth.

FIG. 164 *(bottom).*—Cyst formation of maxillary right lateral incisor, probably resulting from injury to the deciduous teeth.

Figure 164 shows the radiogram of a maxillary right lateral incisor with a large cyst. The patient, a boy of 13, had no discomfort, and the only reason for suspecting the tooth was the extreme mobility of the right lateral incisor. At the age of 4 the boy received a blow from a toy golf stick which displaced the maxillary right deciduous lateral incisor and a portion of the alveolar process. The permanent lateral incisor erupted but had always been extremely loose.

From the evidence presented, it appears possible that traumatic injury to a deciduous tooth may lead to damage of the permanent tooth beneath it.

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NOTE—Asterisk (*) indicates reference to page of illustrations.