A Primer for Osseous Surgery

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Periodontal osseous surgery has been used as a therapeutic modality since the late 1940s when Schlueger introduced it into this country, and since then it has gained many followers. In the early years osseous surgery was primarily compared to the gingivectomy in terms of pocket reduction or elimination. More recently osseous surgery has been evaluated and compared to flap-type procedures using various clinical parameters. Unfortunately, there is a definite disparity between the conclusions of some research reports and the clinical practice of periodontics. The clinician must learn that he must continually deal with the mundane problems of pocket management, and this includes long-term commitments to the patient and the referring dentist. These commitments are expressed in terms of attempts to maintain shallow postoperative sulci without further loss of attachment. It is in this environment that osseous surgery has survived and its prestige has remained intact.

A review of the various standard periodontal textbooks and other publications dealing with osseous surgery reveals that few if any guidelines, rules, or principles are suggested as to when, where, and to what extent bone should be removed or reshaped. A critical analysis of past and current concepts of osseous surgery reveals that the primary objective has been to communicate the subject as an art or technique in which one becomes proficient over a period of years. The types of craters have been identified in the literature and lectures, but the anatomical environment in which the craters exist has never been described. This is the primary reason that we have not been successful in communicating consistent basic principles of osseous surgery that can be repeated. It is natural that proponents of osseous surgery have a wide variety of concepts and interpretations of the procedure based on their educational background, skill, and ability to observe long-term postoperative results.

The purpose of this communication is to present a basic and rational approach for osseous surgery. The principles and guidelines are based on clinical judgment acquired during 30 years of private practice. It is hoped that these guidelines will assist teachers, students, and clinicians to recognize where osseous surgery can be most effectively used as a means of pocket reduction or elimination. The morphology of craters and their relationship to the contigu-
ous bone and root anatomy will be described along with the indications and contraindications for treatment of the various types of craters. The limitations of osseous surgery, in addition to various problems related to reverse architecture, will also be discussed.

Craters and Root Trunk Types

Bony craters are identified according to their morphology and depth. They can generally be divided into three basic types: shallow craters, 1.0 to 2.0 mm deep; medium craters, 3.0 to 4.0 mm deep; and deep craters, 5.0 mm or more (Figs. 1a and 1b).

The primary factor responsible for determining the amount of buccal bone that can be removed in molar areas is the relationship of the base of the crater to the root trunk. Multitraoted teeth have a common root base or trunk that extends from the cementoenamel junction to the furca. In this paper the term root trunk embraces the root trunk proper, the furca, and the marginal bone coronal to the furca.

Once the base of the crater has been identified, the next step is to relate it to the root trunk. Root trunks can be classified as short, average, and long (Figs. 2a and 2b). Generally, the root trunk type determines the amount of bone coronal to the furca. No information is available to indicate that root trunk length influences the dimension between the cementoenamel junction and the marginal bone. Clinical observation and the work of Gargiulo, Wentz, and Orban have indicated that the dimension of root surface from the cementoenamel junction to the crest of the marginal bone is approximately 1.5 to 2.0 mm, depending on the site and tooth involved. Therefore, if a root trunk is 3.0 mm, one might expect to find 1.0 to 1.5 mm of bone coronal to the furca (Fig. 3). This assumes that there has been no loss of attachment in the marginal radicular areas. There are obviously exceptions to this rule because occasionally some molars appear to have a long root trunk due to a tapering crown form. Close examination may reveal a long clinical crown which in fact is due to a cementoenamel junction that is positioned apically, hence the appearance of a long root trunk.

As clinicians, we occasionally notice an exceptionally long root trunk with a casual interest. Also when charting a case we may observe a shallow marginal pocket that invades the furca of a molar, indicating a short root trunk. However, the association between root trunk lengths and surgical therapy has not been reported. Rosenberg has published some interesting clinical observations on furca problems that are worthy of review. Larato designed a study to investigate the influence of the furca position to the cementoenamel junction. The conclusion was that a furca in close proximity to the cementoenamel junction is prone to furca invasion due to the close proximity of gingival inflammation and other factors related to anatomic configurations. Larato’s conclusion has clinical application to osseous surgery, which will be obvious during the discussion on technical aspects of surgery.
Fig. 1a  Classification of maxillary molar craters. A. shallow crater – 1 to 2 mm, B. medium crater – 3 to 4 mm, and C. deep crater – 5 mm or more.

Fig. 1b  Classification of mandibular molar craters. A. shallow crater – 1 to 2 mm, B. medium crater – 3 to 4 mm, and C. deep crater – 5 mm or more.

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Fig. 2a  Classification of maxillary molar root trunks. A. short root trunk – 3 mm, B. average root trunk – 4 mm, and C. long root trunk – 5 mm or more.

Fig. 2b  Classification of mandibular molar root trunks. A. short root trunk – 2 mm, B. average root trunk – 3 mm, and C. long root trunk – 4 mm or more.

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Diagnostic Role of the Radiograph

Accurate radiographic images provide diagnostic information regarding the relationship of the base of the crater to the buccal furca. The radiograph should be an accurate image of the area involved, and this requires a paralleling technique similar to that originated by Fitzgerald and later modified by Updegrave. An excellent publication on the role of the radiograph in the practice of periodontics has been written by Pichard. The radiograph has not been used for therapeutic purposes to identify and relate to structures described above. The successful clinician must anticipate the problems that will be encountered during surgery.

In a radiograph, the base of a shallow crater may be eclipsed by the superimposition of the buccal aspect of the crater over its lingual counterpart (Figs. 4a and 4b). Shallow craters have thick buccal and lingual aspects due to their gradual slope to the base. Therefore, the radiograph will probably not depict the base of the shallow crater and the bony defect will often be more severe than anticipated. This may not prove to be a problem for a tooth with a long root trunk, but a shallow crater in the presence of a short root trunk will certainly require more precise judgment.

Limitations of the radiograph as a diagnostic tool have been emphasized along with the many benefits it offers to the clinician. The use of the radiograph in detecting the base of the crater and relating it to the root trunk is more accurate for mandibular molars than for maxillary molars because of anatomical limitations in the maxilla. Correlating the base of the crater to the root trunk of maxillary molars can best be done using the interproximal bite-wing film.

The use of the radiograph to orient the base of the crater to the furca can...
Fig. 4a. The shallow crater and the radiograph. The buccal aspect of the crater, BA, is superimposed on the lingual aspect, LA, and the base of the crater, BC, is often obliterated.

Fig. 4b. Radiographic image of a shallow crater. The base of the crater, BC, is not visible in the radiograph since it is masked by the interdental bone height.

Fig. 5a. Shallow craters associated with short root trunks.

Fig. 5b. Shallow craters associated with average root trunks.

Fig. 5c. Shallow craters associated with long root trunks.

Fig. 5d. Medium craters with interdental bone levels equal to the buccal.

Maxillary Molars

Shallow Craters
- Short root trunks
- Average root trunks
- Long root trunks

Medium Craters
- Short root trunks
- Average root trunks
- Long root trunks

Deep Craters
- Short root trunks
- Average root trunks
- Long root trunks

Fig. 6. Maxillary molars and the various combinations of craters and root trunks.

be demonstrated by the following series of radiographs. Figure 5a represents shallow craters in the presence of short root trunks, Fig. 5b shows shallow craters associated with average root trunks, and Fig. 5c demonstrates shallow craters in conjunction with long root trunks. All of these cases had normal sulci on buccal and lingual marginal areas. Figure 5d reveals medium craters with an incipient furcation invasion on the first molar and normal sulcular depth on buccal and lingual radicular areas of the second molar. The interdental bone level between the molars is apical to that of the furcas. Consideration should also be given to the fact that the radiograph shows the interdental bone level and not the base of the crater.

Maxillary Arch Craters – Molar Area
Shallow, medium, and deep craters involving the maxillary molars will be discussed as each relates to short, average, and long root trunks (Fig. 6). For purposes of establishing rules, guidelines, and general clarification, all three types of craters involving the maxillary molars will be reviewed in their classic forms. Classic forms refer to situations where craters are present without probeable depths in the radicular areas. Furcation invasions associated with interdental bony craters are obviously common problems concerning the therapist, and they will be discussed in detail.

Historical Aspect
Prior to the 1960s osseous surgery for maxillary molar craters was usually performed from the buccal aspect. The primary reason for this method was that the buccal aspect offered greater accessibility to a therapist and the buccal gingival recession achieved was more accessible to hygiene efforts by the patient. This standard method of approach to the molar crater problem offered certain benefits but these were offset...
by some undesirable factors. Ochsenbein and Bohannon described the palatal approach to solve some of the problems associated with the standard buccal approach. In general, the palatal approach took advantage of anatomical factors in the molar area and changed the recession from the buccal aspect to the palatal aspect.

The primary objections to the buccal aspect of reducing craterers at that time were (1) buccal recession, (2) reversed architecture, (3) sacrifice of buccal radicular bone, and (4) inadequate buccal interdental spaces between the molars.

In summary, the palatal approach was a significant improvement in the management of the molar area since it was based on the relationship of the crater to regional anatomy. It represented a departure from the standard buccal approach. The palatal approach has stood the test of time and is currently being used by many practicing clinicians. However, more than 20 years have passed since its original presentation and certain revisions and refinements have been made in recent years.

Shallow Craters

The interdental shallow crater is the most common lesion found in periodontitis. The buccolingual morphologic normal of the interdental bone is relatively flat in most maxillary molar areas and minor interdental alterations will frequently create a shallow crater. The shallow crater of 1.0 to 2.0 mm depth has a gradual decline from the buccal and palatal aspects to the base, which is concave and never has flat topography (Fig. 7). Most such craters can be managed from the palatal aspect, which represents the palatal approach in its pure form. This means that the level of the marginal bone on the buccal aspect of the crater will remain intact. Therefore, management of the shallow crater in the maxillary molar area is the same for short, average, and long root tooth.

It should be pointed out that the slope or ramp placed on the palatal bone is extremely important and this aspect of bone surgery is often disregarded. An exaggerated slope is contraindicated because it requires excessive removal of palatal radicular bone in order to avoid creating reversed architecture. Entirely too much osseous surgery is performed with a slope that is too severe and is followed by the needless removal of supporting bone on the adjacent teeth.

The inclination of the slope of the palatal bone should be approximately 10° apical to an imaginary horizontal line representing the base of the crater (Fig. 8). Admittedly, a palatal slope of 10° may be somewhat difficult to assess at the time of surgery, but it will become more realistic with practice. A relatively safe method for establishing a proper degree of slope is to first flatten the palatal aspect of the crater with no slope being created. With this as a guide the slope can be gradually increased from the flat or horizontal level to one of greater incline. After the palatal aspect has been prepared, a curette can be placed on its backside and moved from buccal to palatal across the surface of the interdental bone. With some effort of practice, it will become a simple matter to detect the presence or absence of a bony crater or minute inconsistencies in the surface of the interdental bone.

Once the palatal slope has been properly performed, the palatal interdental height will usually be apical to the adjacent palatal radicular bone. The radicular bone will then be removed until it is level with or slightly apical to the interdental bone. Therefore, it can readily be seen that the degree of slope established in the interdental palatal bone determines the amount of palatal radicular bone removed.

It is common for the shallow crater to have a broad or thick buccal aspect which may be managed without any reduction of the buccal marginal or supporting bone. Under these circumstances minimal postoperative gingival recession would be expected.

Radicular bone thickness depends primarily on the tooth to bone relationship existing in the area. Radicular bone covering the mesiobuccal root of the first molar is usually thin and may have a dehiscence or fenestration. Abrams has observed that the mesiobuccal root is prominent because the tooth is normally rotated to the buccal. This rotated position also accounts for the fact that the distobuccal root may have relatively thick radicular bone. Since the distobuccal root frequently flares distally toward the mesiobuccal root of the second molar, there may be a constriction of the interdental space between the two molars. Furthermore, while the first molar is ordinarily in a vertical position, the second molar is usually tilted buccally with the roots projecting toward the palate. The palatal inclination of the buccal is responsible for thick buccal radicular bone, which is
a very common finding in this area. If a buccal flap procedure reveals excessive thickness of the buccal bone adjacent to either molar, thinning of the buccal marginal bone is appropriate. It should be emphasized that this procedure should not influence the height of the buccal radicular or interdental bone.

Medium Craters

Medium craters in the maxillary molar areas are 2.0 to 4.0 mm deep. Furthermore, they have a somewhat different morphology than the shallow craters due to their more precipitous drop from the height of the interdental buccal and palatal aspects to a flatter type base (Fig. 9). Medium craters—generally cannot be managed by the palatal approach or palatal reduction alone and will require buccal osseous procedures as well. There are exceptions to this rule that the clinician should understand. The exceptions are based on anatomical factors and will be discussed in detail. Management of the buccal aspect of medium craters will vary depending on the dimension of the root trunk. This was not a factor with shallow craters, therefore medium craters require more clinical decisions and expertise than shallow craters.

The first step in managing medium maxillary molar craters is to reduce the palatal aspect following a procedure similar to that suggested for shallow craters. The palatal aspect of the crater is leveled first and then an approximate 10° slope is placed on the palatal bone profile (Fig. 10). Although the slope is similar to that of the shallow crater, it is in a more apical position in relationship to the root of the teeth involved due to the greater depth of the crater. Any attempt to eliminate a medium crater solely from the palatal aspect by a severe slope would prove disastrous and necessitate excessive removal of palatal radicular bone. Therefore, after management of the palatal as-

pect of the crater as outlined, one must consider reduction of the buccal interdental bone. However, before any buccal reduction of bone, it is important to relate the base of the crater to the root trunk or more specifically to the position of the buccal furca. Teeth with short root trunks associated with medium depth craters will be discussed first, then average and long root trunks.

Short Root Trunks. A medium crater associated with a short root trunk involving the first molar will often have a furca that is approximately 3.0 mm from the cementoenamel junction. It is then considered that the normal position of the marginal radicular bone is approximately 1.5 to 2.0 mm apical to the cementoenamel junction, it becomes obvious that the marginal radicular bone is approximately 1.0 mm coronal to the furca (Fig. 11). Therefore, the amount of marginal radicular bone is critical and should concern the clinician. The root trunk of the second molar is slightly greater than the first molar and there may be 1.0 to 2.0 mm of marginal radicular bone present when the root trunk is short.

Once the buccal aspect of the molars has been appraised, the initial procedure is to manage the palatal aspect of the crater with the proper 10° slope. The tendency is to make a greater than 10° slope when managing the medium crater.

If medium depth craters exist mesial and distal to the first molar in the presence of a short root trunk, buccal reduction of the craters would be poor surgical judgment. The importance of the buccal dimension of available bone cannot be ignored. Leveling of the buccal aspect would place the buccal interdental bone height apical to the position of the buccal furcas. Reversed architecture is created and the first molar is the primary problem area. If a slope is created instead of a leveling procedure the reversed architecture is even more severe. Once the re-

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Fig. 11. Medium crater with a short root trunk. A, palatal reduction; BR, and buccal reduction; BR would allow buccal interdental bone levels apical to the furca. B, the effects of buccal reduction-reversed architecture.

Fig. 12. A, compromise therapy for medium crater with a short root trunk. Standard palatal reduction is performed and the buccal aspect of the crater remains unaltered. B, the results of compromise are expressed in pocket depth. P. However, this compromise is preferred to the result in Fig. 11b.
versed architecture has been intentionally or inadvertently created it cannot be remedied because there is little or no buccal radicular bone available for reduction in order to create similar levels of bone in interradicular and radicular areas. On the other hand, the second molar offers some degree of flexibility due to the greater dimension of the buccal root trunk and the probability that a greater amount of radicular bone is present coronal to the buccal furca. The radicular bone may be reduced to alleviate minimal problems of reversed architecture in certain circumstances. However, the area that concerns us most is that of the first molar and this area is the primary location of reversed architecture following osseous surgery.

Since the buccal interradicular bone—presenting the buccal component of the medium crater should not be reduced apical to the positions of the buccal furca of the molars with short root trunks, it is almost certain that compromise will be necessary. The buccopalatal morphology of the interradicular bone will not be a gradual slope to the palate because varying degrees of the crater’s buccal component would still be present. During the early healing period the gingiva will follow the bony profile with a shallow gingival crevice. However, within four to eight months the gingiva will bridge the interradicular bony oaberation and a papilla will form with concomitant pocket formation [Fig. 12]. The postoperative result will be a compromise in terms of pocket reduction but it is a far better compromise than creating reversed architecture, which would likely contribute to bone loss in the furca area.

It is obvious that medium depth craters associated with short root trunks represent unique problems that are difficult to manage. The percentage of cases with short root trunks in the maxillary molar areas appears to be minimal. However, when this anatomical form is present, percentages become unimportant and the case at hand becomes 100%.

Medium Root Trunks. The medium depth crater with an average root trunk has a better prognosis and more flexibility in treatment than the previously described situation dealing with a short root trunk. The average first molar root trunk has a buccal furca, which is approximately 4.0 mm from the cementoenamel junction and this would indicate that approximately 2.0 mm of buccal radicular bone is present coronal to the furca. The second molar has a root trunk of 4.0 to 5.0 mm and this would mean that approximately 2.0 to 3.0 mm of bone is coronal to the furca.

The palatal aspect of the crater is managed as previously described for a medium crater with an estimated 10° slope to the palate. After performing the palatal correction, attention is directed to the anatomy of the buccal aspect of the crater. Perhaps the first thought would be that it is possible to eliminate the crater by flattening the buccal aspect (Fig. 13). On the surface, totally eliminating the offending projection of bone, might seem to be the proper approach to the problem. Assuming that the buccal interradicular height was reduced some 3.0 mm by this procedure, a corresponding 3.0 mm of radicular bone would need to be removed in a buccal radicular area. If one then refers to the dimensions of radicular bone that is coronal to the furca, it becomes obvious that the surgeon is operating under marginal circumstances and there is even a very good chance that reverse architecture will result. At best, the buccal interradicular bone height mesial and distal to the first molar would be on a similar level with the buccal radicular bone and the furca. However, the astute clinician should be troubled even with this result. First, there is little or no bone coronal to the furca and any future inflammation of the gingiva could precipitate an invasion of the furca with only shallow pocket depth. A correlation should be made between this situation and Laroo’s conclusions concerning furca proximity to the cementoenamel junction. An additional factor concerns buccal recession of this magnitude in the molar area. While early healing may present a thin well adapted gingival margin, there is a propensity for developing a thick, fibrotic, rolled margin even in the presence of good hygiene.

The best approach would be to maintain some of the buccal interradicular bone height and not eliminate all of the bony defect. Obviously, this method would also retain more bone coronal to the furca of the first molar [Fig. 14].

The “leveling” or “beveling” of the buccal aspect of the medium crater associated with an average root trunk is an important issue. The buccal aspect can be managed in a variety of ways and each will have a different effect on the buccal radicular bone (Fig. 15). The buccal aspect can receive partial reduction, leveling reduction, beveling reduction, and positive reduction. Partial reduction will not eliminate the crater and one can expect varying degrees of
Fig. 13. Medium crater associated with an average root trunk. A. palatal and buccal reduction. B. buccal reduction removes minimal bone slightly apical to the furca.

Fig. 14. Compromise therapy for medium crater associated with an average root trunk. A. partial reduction of the buccal aspect of the crater. B. retention of bone coronal to the furca. Barney crater should not be totally removed.
Fig. 15 Variations in methods of managing the buccal aspect of the crater and their influence on the buccal and lingual bone. A. partial reduction, B. leveling reduction, C. beveling reduction, and D. positive reduction.

Fig. 16 Medium crater associated with a long root trunk. A. palatal reduction and leveling of the buccal aspect of the crater or buccal reduction. B. considerable dimension is present between the marginal bone and the furca.
pocket depth returns. Leveling reduction may be an acceptable solution for many problems provided the leveling procedure does not place interdental bone levels apical to the furca. Beveling reduction will often create various degrees of reversed architecture and in general should be used with caution. Positive reduction will create severe reversed architecture. Diagrams in various publications that demonstrate craters and the proper bevels necessary for crater elimination only show the interdental aspect of the crater problem.

The second molar, as mentioned previously, does not pose as great a problem as the first molar and can usually afford more reduction of the buccal root bone. However, the problem of buccal recession still exists on the second molar and this factor should always be considered.

The long-term postoperative result of maintaining the maximum buccal bone height will reward the therapist for his efforts in terms of clinical success.

Long Root Trunks. The medium depth crater associated with a long root trunk definitely offers the most flexibility in management of bony lesions. Long root trunks have a buccal dimension of 5.0 mm or greater on the first molars with 3.0 mm or more of buccal root bone coronal to the furca. Second molars have a 6.0 mm or greater buccal root trunk with 4.0 mm or more of root bone coronal to the furca.

If management of the palatal aspect of the crater is followed as suggested, the buccal aspect of the crater is surveyed and related to the buccal anatomy. The base of the crater will be coronal to the level of buccal bone ridging and this would indicate the buccal aspect of the crater to be leveled and that the buccal root bone could be reduced, leaving root bone coronal to the furca of the first molar (Fig. 16). Again, a relatively flat architecture would have been produced. Even though there may be bone coronal to the furca, the amount of recession remains a factor of concern and must be considered on an individual basis.

Deep Craters

Since deep craters represent advanced periodontal disease, it is important to state emphatically that osseous surgery has only a limited role in the management of such cases. It can serve a useful purpose under certain conditions. Craters can be minimized along with other bony aberrations, but basic goals of therapy must be revised and altered.

Deep craters associated with maxillary molars are 5.0 mm or greater in depth. Since they are extensions of medium craters, they are usually seen with buccal and palatal aspects that are even more precipitous than that seen in medium craters (Fig. 17). The buccal aspect of the crater is usually thin due to the broad semi-flat base. The thickness of the palatal aspect of the crater will ordi-

nantly hinge on the type of vault present, that is flat or steep. Deep craterers also have a wide buccopalatal dimension and may extend too or beyond the line angles of the molars.

The palatal reduction of a deep crater should never be more extensive than that advocated for a medium crater. It should be pointed out that the palatal aspects of the craterers cannot be leveled as was done for medium craterers. If the palatal aspect of the deep crater is totally reduced, it will involve excessive removal of radicular bone.

The management of the buccal aspect of the deep crater associated with a short root trunk is the same as that suggested for the medium crater and a short root trunk. The buccal interdental bone height can tolerate little or no reduction because there is probably no bone available for removal coronal to the buccal furca.

Deep craterers in the presence of average or long buccal root trunk should be subjected to the same rules given for the medium crater (Fig. 18). The buccal interdental bone height cannot be reduced apical to the position of the buccal furca and the recession should be kept to a minimum by maintaining as much buccal bone height as possible.

Earlier in this report it was stated that all three types of craterers will be reviewed in the classification with shallow crevices present in the radicular areas. It should be mentioned that the classic form of deep craterers by this definition does not represent the majority of cases. Deep craterers are found with advanced periodontal disease and deep pockets are usually present in varying degrees on buccal and palatal surfaces. This aspect of therapy will be discussed later along with furcation invasions as they relate to the management of craterers.
Maxillary Premolars

The management of premolars and the anterior teeth offer interesting therapeutic challenges for the clinician. As the transition is made from the maxillary labial to the premolars, the buccolingual dimension of the bone is frequently thick. This often results in shallow well-like defects on the palatal root of the second premolars. These wells are usually confined to the mesial palatal to distal palatal line angles of the premolars. These defects are usually from 1.0 to 2.0 mm deep and can be reduced by osteoplasty procedures.

The maxillary first premolar is a challenging tooth to manage when even a minor osseous defect exists. Isolated pockets are commonly found in this area of otherwise healthy dentitions. Efforts to maintain periodontal health in this area have not been impressive. Access is poor for oral hygiene aids because of the concave root surface exposed by the pocket. Furthermore, it is a difficult pocket to instrument by the periodontist or the experienced hygienist. The maxillary first premolar is frequently bifurcated and, considering the proximity of the mesial furca to the cementoenamel junction, a seemingly incipient lesion can have serious implications in treatment. Fortunately, the greatest interdental pocket depth is usually located palatally and many shallow craters are amenable to palatal reduction. If the crater is of medium depth, buccal reduction will also become necessary. In this regard, the buccal aspect of the interdental crater should be reduced gradually with careful observation because gingival recession may create an aesthetic problem.

Basker has made some interesting observations concerning the maxillary first premolar. He states that single rooted teeth have a 0.56 to 0.59 mm deep mesial concavity and that double rooted premolars have 0.50 to 1.00 mm deep mesial concavities. Both single and double rooted teeth have from 1.40 mm to 1.60 mm of dentin and cementum external to the pulp canal. If one attempts to eliminate the concavity by odontoplasty as is sometimes advocated, the single rooted teeth would have only about 0.90 mm of dentin remaining to protect the pulp. Odontoplasty to this area should be approached with caution because it may precipitate a pulp death.

Perhaps the primary implication regarding the maxillary first premolar is that pocket management should be initiated at an early date when the prognosis is favorable. A shallow crater in this area can ordinarily be managed very well from the palate.

Maxillary Anterior Teeth

Goals of pocket elimination or reduction must be revisited when dealing with the maxillary anterior teeth due to esthetic demands. Although each case must be evaluated on an individual basis, generally if pockets are 5.0 mm or more in depth, a compromised procedure must be considered. A flap approach and curettage, modified Widman flap, or other forms of flap procedure are usually indicated. Minimal flap retraction is performed without any retraction apical to the mucogingival junction, which minimizes flap shrinkage. Precise incisions, careful root preservation, and proper flap adaptation will favorably influence the result. However, a new connective tissue attachment to the previously diseased root surface is remote, and any change in probeable depths will likely result from shrinkage of the gingival margins.

Caton and Nyman's research has shed considerable light on this subject and it is important to understand that flap-type procedures do not produce some type of neubulous attachment to the root surface. These authors performed a histometric evaluation of the modified Widman flap procedure and observed that the procedure produced no gain in connective tissue attachment and no increase in crestal bone height. A long junctional epithelium along the treated root surface was the end result. A long junctional epithelium has been evaluated by the research of Beaumont et al. Their conclusions were that there appeared to be no appreciable difference in resistance to disease between a long junctional epithelial adhesion and a true con-
mandibular molars

shallow craters
- short root trunks
- average root trunks
- long root trunks

medium craters
- short root trunks
- average root trunks
- long root trunks

deep craters
- short root trunks
- average root trunks
- long root trunks

fig. 19 mandibular molars and the various combinations of craters and root trunks.

nective tissue attachment. While this research cannot be ignored, many clinicians have trouble making a correlation between their findings and clinical periodontics.

A flap procedure has merit in that it affords accessibility to the root surfaces, which closed curettage does not offer. Pocket depths remain but maxillary anterior teeth are more accessible to maintenance procedures than posterior teeth. If deep pockets cannot be maintained and attachment continues to be lost, it may be necessary to resort to extractions. In any case, the esthetic factor associated with maxillary anterior teeth is critical for many patients and should be given priority. The exception to the above would be situations where the anterior teeth are to receive full coverage restorations. Pocket reduction or elimination procedures with or without osseous surgery should be considered when extensive restorative procedures involve anterior teeth.
Mandibular Arch Craters — Molar Area

Shallow, medium and deep craters involving the mandibular molars will be discussed as each relates to short, average, and long root trunks (Fig. 19).

In many respects, osseous defects in mandibular molar areas are the most difficult of all bony defects to manage. The anatomy of the area is undoubtedly responsible for much of this difficulty. Proper access for lingual osseous surgery requires certain modifications and other changes in operating procedures. The service of a well trained assistant is mandatory since the retraction of the tongue and aspiration of fluids are essential for clear vision of the area. Problems of lingual osseous surgery are more demanding than other areas. Perhaps the best general description of osseous surgery as it is being practiced in mandibular molar areas is that it is "over treated" on the buccal aspects and "undertreated" on the lingual aspects.

Before discussing the mandibular molar problem, it is important to review regional anatomical factors. The lingual inclinations of the mandibular molars will play an important role in the management of the area; however, our information on the subject is indeed sparse and vague. When specific lingual inclinations of the molars are mentioned in the periodontal literature, the reference most frequently cited is a publication by Dempster, Adams, and Duddles. The tooth inclinations described in this report seem to have been generally accepted as accurate and representative of average anatomical situations. However, it is significant to mention that this statistical data was taken from 11 skulls.

Since such a small sample was used in the study, the validity of these figures is questionable. In the Dempster study, it was suggested that the first and second molars have a lingual inclination of approximately 20° to a vertical axis. After observing several hundred skulls, it seems that the 20° inclination for the first molar is reasonably accurate. However, the second molar in most of the skulls observed has a greater inclination than the first molar. Therefore, it is this author's impression that the second molar has an inclination of 25° or greater (Figs. 20a and 20b).

The lingual inclination factor is not just an academic consideration; it is relevant because the base of the crater is usually located apical to the contact area. Since the crater base is vertical to the contact area, the greater the lingual inclination of the molar, the more lingual the deepest aspect of the crater. If, for example, the molars had no lingual inclination and were in a vertical position, the crater base would likely be located midway buccolingually. It will be shown that these anatomical observations will influence the technical aspects of osseous surgery. Shallow and medium depth crater types generally have their bases located lingually while deep craters usually have no specific morphological pattern.

Becker has observed, on various occasions, that the mandibular second molar can present with considerably more mesial inclination than that seen in the normal. This type of inclination will obviously create a discrepancy between the cementoenamel junctions of the two molars along with a precipitous drop of the second molar mesial interdental bone height. This would, in effect, create a fertile area for a hemiseptum type defect. Management of this area is often difficult because of the variations in bone levels.

The root trunk dimension of any given molar is usually 1.0 mm greater for the lingual aspect than for the buccal aspect (Figs. 21a and 21b). Also, the buccal aspect frequently has a developmental depression that extends coronally from the frena and fades out immediately below the cervical line.

A comparison of buccal and lingual gingival architecture in the mandibular molar area may have certain clinical implications. The buccal gingival architecture between the molars is frequently flat or relatively flat; that is, the interdental papilla is 1.0 to 2.0 mm coronal to the buccal marginal gingiva. However, on many occasions the buccal architecture may be more scalloped, with 3.0 to 4.0 mm of interdental height. When the lingual gingival architecture is noted on such a case the lingual aspect usually has a flat architecture (Figs. 22a and 22b). Therefore, most lingual gingival architecture is flat regardless of the architecture type on the buccal aspect.

In view of the lingual inclination factor, the greater dimension of the lingual root trunk, and the flat lingual architecture finding, sloping the craters to the lingual aspect and terminating with a flat osseous architecture seems to be a rational approach.

Fig. 20a. Lingual inclinations of the mandibular molars. A. first molar with 20° inclination. B. second molar with 25° or greater inclination.

Fig. 21a. Comparison of mandibular first molar buccal and lingual root trunks. Buccal view.

Fig. 20b. Dry skull view of mandibular molars. The second molar has considerably more lingual inclination than the first molar.

Fig. 21b. Lingual view shows a typically greater dimension of the root trunk as compared to the buccal.

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Fig. 22b. Comparison of mandibular molar, buccal and lingual architecture. Sclerosed buccal architec-
ture.

Fig. 22b. Flat lingual architecture.

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Shallow Craters

Shallow craters in the mandibular molar areas are common and generally are good candidates for successful osseous surgery. Shallow crater depth for the mandibular molars is 1.5 to 2.0 mm similar to that previously discussed for the shallow craters associated with maxillary molars (Fig. 23). However, their morphology is somewhat different from maxillary molar craters. Since the deepest probeable pocket depth is vertical to the contact area, which is positioned lingually, the base of the crater is usually located near the junction of the lingual one-third and the middle one-third. This being the case, there is a long lingual slope from the buccal aspect to the base of the crater (Fig. 24). It is important to observe this anatomical fact because treatment for the shallow crater is based primarily on this factor.

The first obstacle in managing shallow lesions for this region is the reduction of the thick lingual bone that is usually present. This thick, lingual shelf of bone is primarily influenced by the mylohyoid ridge and it varies considerably in its morphology. The mylohyoid ridge passes downward and forward from the ramus of the mandible and usually terminates by blending into the inferior portion of the alveolar process in the premolar region. Its maximum thickness is usually adjacent to the second molar area and begins to diminish in varying degrees in the first molar region. Therefore, the second molar with a greater lingual inclination coupled with a prominent mylohyoid ridge usually has a considerable bulk of lingual bone. Gingiva covering thick lingual bone creates an excellent environment for plaque retention, and it is common to observe various depths of lingual intrabony or trough-like defects in this area.

The bevel needed for the lingual bone is difficult to express in terms of

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average because the bevel will depend on the lingual inclination of the molars on an individual basis and also the morphology of the lingual bone. Usually a near vertical bevel can be placed on the lingual bone of the first molar due to the lesser inclination and thinner lingual bone. On the other hand, the second molar will often have a wide mylohyoid ridge occlusoapically, which would make impractical a vertical bevel such as perhaps was done on the lingual bone of the first molar (Fig. 25).

Following the osteoplasty procedure of shaving and beveling the lingual bone, an interesting situation can be observed. The beveling procedure removes a dimension of the lingual aspect of the crater, which in effect places the base of the crater in closer proximity to the lingual marginal bone. Also, consider the morphology of the shallow crater with its long lingual slope from the buccal aspect to the base of the crater. When these two factors are brought into perspective, it follows that the amount of lingual bone removal or osteotomy necessary to eliminate the lingual portion of the crater is indeed minimal. This is a key factor in the management of the mandibular shallow crater. The removal of this small portion of bone creates a continuation of the long lingual slope

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a short root trunk should cause concern. Removing 2.0 mm of lingual interdental bone height will likely cause some reversed architecture (Fig. 27). Therefore, when radiographs and clinical observation reveal a short root trunk, a safe method would be to reduce the height of the lingual aspect of the crater and the lingual radicular bone simultaneously. When it is evident that the lingual furca is being approached, no further reduction of bone should be performed in radicular or interdental areas. If both radicular and interdental areas were concomitantly reduced, the radicular and interdental levels of bone would be similar. However, if the radicular and interdental bone has been reduced to the level of the furca and there is still residual crater depth in the interdental areas, the clinician has two options. First, he can accept the residual crater depth and the pocket depth that follows. On the other hand, the lingual aspects of the crater can be reduced further but reversed architecture is certain. The choice of the two options is a judgment decision and the clinician can consider the options.

The buccal interdental bone associated with shallow craters will often appear thick and a subtle interdental sluiceway may be indicated. The height of the buccal interdental bone should not be reduced when managing a shallow crater. Deep buccal precipitous interdental sluiceways or groove-like procedures should be avoided because the gingiva will not conform to this topographical form. Furthermore, the danger of inadvertently reducing the buccal interdental bone height.

Shallow craters in the presence of an average root trunk can be managed from the lingual aspect without any complications due to the greater dimension of the lingual radicular bone as compared to the short root trunk (Fig. 28).

Shallow craters associated with
Fig. 27. Mandibular molar shallow crater associated with a short root trunk. A. Buccolingual view. Thick lingual bone beveled by osteoplasty, OP. Minimal osteotomy is done to reduce lingual aspect of the crater, OE. B. Buccal aspect. Forcs, F, is in close proximity to the buccal marginal bone. C. Lingual view. Reduction of lingual aspect of crater by osteotomy, OE, will place interradicular bone levels apical to forcs, F.

Fig. 28. Mandibular molar shallow crater associated with average root trunk. A. Buccolingual view. Thick lingual bone beveled and lingual aspect of crater reduced. B. Buccal view. Force, F, is protected by adequate coronal bone. C. Lingual view. Reduction of lingual aspect of crater does not create reversed architecture due to root trunk dimension.
long root trunks obviously have an even greater degree of flexibility than the average root trunks, but are managed the same as average root trunks. It should be understood that the buccal interdental bone heights of shallow craters should not be altered regardless of the root trunk type.

In the past there has been considerable reluctance to expose the mylohyoid ridge by a flap procedure. Various claims have been made, but essentially the problems of severe postoperative pain and the possibility of cellulitis have prevented many periodontal surgeons from exposing this area. It is difficult to become concerned with a proper bevel of thick lingual bone when the clinician is not aware that the thick bone exists. Problems with classic cellulitis are rare but various degrees of edema are commonly associated with any type of mandibular molar surgery. Prolonged severe pain is not a common postoperative sequella for osseous surgery. However, mild pain of short durations is commonly associated with mandibular molar surgery, but it can usually be controlled with analgesics. It should be stressed that precise incisions in the mandibular lingual gingiva and careful retraction of the lingual flap are essential. Excessive retraction of improperly designed flaps will elicit more postoperative pain than the removal of bone.

Medium Craters

Medium craters in this area are 3.0 to 4.0 mm deep and there is usually a considerable decline from the buccal and lingual aspects to a somewhat flat based (Fig. 29). Shallow mandibular molar craters are often overlooked but the medium craters are distinct and evident. Medium craters in this area are undoubtedly the most difficult to manage of all craters. With determination and experience the clinician should be able to make an ongoing appraisal of the osseous

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Fig. 30: Mandibular molar medium crater associated with short root trunk. A. buccal-lingual view. Thick lingual bone beveled and lingual aspect of crater reduced. B. buccal view. Fura is at or near the buccal marginal bone. C. lingual view. Reduction of the lingual aspect of the crater will produce reversed architecture. Compromise should be considered instead of reversed architecture.

morphology and its contiguous environment as it is being influenced by osseous surgery. The medium crater has the potential to become an architecturally acceptable postoperative result. However, it has the potential to become a periodontal disaster when mismanaged.

Short Root Trunks. The incidence of mandibular molar short root trunks is probably 30% to 35%. Of these, the majority will have less than 1.0 mm of bone coronal to the buccal furca and a lesser number will have practically no bone coronal to the furca. The lingual furca will usually present with a 1.0 mm greater dimension of bone coronal to the furca than that seen on the buccal aspect. Considering the 3.0 to 4.0 mm crater depth and the likelihood of having 2.0 mm of bone coronal to the lingual furca, it is obvious that a potential problem exists (Fig. 30). Under these circumstances, the interdental bone height and the radicular bone are removed concomitantly. When the coronal concavity of the furca groove is first evident upon the removal of the coronal bone, there should be no further reduction of the interdental and radicular bone.

If buccal interdental bone is thick, as is often the case, bone can be contoured properly without influencing the height of the bone. Therefore, the medium crater with a short root trunk in the mandibular molar area is a compromise, as it was for the maxillary molar situation.

There is one favorable aspect of this area that deserves mention. Due to the divergence of roots the mesiodistal dimension of the lingual interdental bone usually increases with a reduction of vertical height. With this increased dimension it is possible to have some minor reversed architecture, and it can be tolerated in many circumstances. Minor reversed architecture is more likely to be compatible with health on the lingual aspect than on the buccal.

Medium Root Trunks. Medium root
Fig. 31 Mandibular molar medium crater associated with average root trunk. A. buccolingual view. Thick lingual bone beveled and lingual aspect of crater reduced. B. buccal view. Furca should usually have approximately 1 mm of bone coronal to furca and should not be reduced in height. C. lingual view. Reduction of the lingual aspect of the crater will produce minor splinted architecture.

Fig. 32 Mandibular molar medium crater associated with killing root trunk. A. buccolingual view. Thick lingual bone is beveled and the lingual aspect of the crater is reduced. The long root trunk will permit some reduction or osteotomy. B. buccal view. Buccal reduction or osteotomy. C. lingual view. The lingual reduction will ordinarily not invade the furca.

trunks occur with a slightly greater frequency than short root trunks. As stated previously, the lingual bone should first be contoured with an osteoplasty procedure. The medium root trunk has a buccal dimension of approximately 3.0 mm with a 4.0 mm measurement on its lingual aspect. The increased length of the lingual root trunk is advantageous in the removal of the medium depth crater from the lingual aspect. Although the medium root trunk anatomy offers some benefits, total reduction of the lingual aspect of the crater may create minor reversed architecture (Fig. 31). Also, the clinician has the option of eliminating the reduction of the lingual aspect of the crater at the level of the furca. Following this decision, attention is directed to the buccal aspect. An average root trunk has approximately 1 to 1.5 mm of bone coronal to the furca, and careful observation of the radiograph along with clinical examination will assist in determining if the buccal aspect of the crater can be altered. With this information, consideration can be given to partial reduction of the buccal aspect. Obviously, this should be done with care and precision. Documentation of cases and observation of the subtle changes in the periodontium for better or for worse is a sine qua non in periodontics.

Long Root Trunks. The long root trunk dimension for mandibular molars is usually 4.0 to 6.0 mm in length and represents the smallest percentage of the three types. The long root trunk obviously offers the clinician considerable latitude when associated with medium craters (Fig. 34). However, this favorable anatomy should not be interpreted to mean that the clinician can ignore conservative osseous surgical principles. Extensive recession associated with long root trunks is often reflected in thick, fibrotic, rolled gingival margins. Therefore, buccal recession is also a real concern even with long root trunks and should be kept to a minimum. On the other hand, lingual osseous surgery is usually well tolerated in the presence of long root trunks.

Deep Craters

Deep craters in the mandibular molar region are represented by depths of 5.0 mm or greater. They are usually seen with buccal and lingual aspects that have a definite precipitous slope to a broad and rather flat type base (Fig. 33). They are often seen to extend beyond the line angles of the molars involved and this pattern is seen more frequently involving the lingual aspect. Any form of osseous surgery for deep lesions should be used with the utmost caution and only by an experienced clinician because these lesions have many limitations. The bony aberrations in advanced disease are bizarre and it is an easy matter for the clinician to become involved in such a case and suddenly find himself beyond his intentions or capabilities. A good safe rule is to carefully survey the bony defects and consider the various possibilities, which might include bone regenerative procedures, bone grafts, root amputation, minor osseous surgery, or selective extraction.

The diagram (Fig. 34) depicts a deep crater associated with an average root trunk. Lingual reduction of the crater is terminated at the level of the lingual furca, which will obviously

leave residual crater depth. The height of the buccal marginal bone should receive minor or no reduction.

In Fig. 35, a deep crater is shown associated with a long root trunk. The increased root trunk dimension will allow a somewhat greater resection of the lingual aspect of the crater and minor alteration of the buccal marginal height.

With some experience the clinician should be able to determine the amount of osseous reduction that the crater will accept prior to the actual performance of surgery. This is important, particularly when dealing with deep craters.
Fig. 33 Mandibular molar deep crater.

Fig. 34 Mandibular molar deep crater associated with narrow root trunk. A. buccolingual view. Thick lingual bone bevelled. Reduction of the lingual aspect of the crater is compromised. B. buccal view. Minimal bone is present coronal to furca and should not be reduced. C. lingual view. Lingual reduction of crater is limited to the level of the position of the furca. Note in "A" that the deep crater has not been resolved.

Fig. 35. Mandibular molar deep crater associated with long root trunk. A. buccolingual view. Thick lingual bone is beveled and the lingual aspect of the crater will tolerate more reduction due to the long root trunk dimension. B. buccal view. Some reduction of the buccal aspect of the crater can be done but bone should remain coronal to the buccal force. C. lingual view. Lingual aspect of the crater has been reduced to level of the lingual force. Note in "A" that much of the deep crater remains and should not be resolved with osseous surgery.

Mandibular Molar Over treatment

Over treatment in any therapeutic modality is a subject of concern. An effort to address the issue involves various considerations. As clinicians, we easily lose our orientation and perspective of the anatomical circumstances when we become involved with the mandibular molar area. Experienced practitioners know that this area is difficult and perplexing.

Figure 36 will provide some analytical insight into the "over treatment" of the buccal mandibular molar c. j. An interdental crater between the mandibular first and second molars is depicted with the second molar at a 25° inclination to a vertical axis. If a line is drawn that extends across the most coronal projections of the buccal and lingual aspects of the crater, this line A would be approximately 25° to a horizontal plane. Then, if an imaginary line B were drawn that traverses the base of the crater and is also parallel to line A, the line B would obviously be 25° to a horizontal plane. It becomes evident that the buccal aspect of the crater would be eliminated by removing bone coronal to line B. Due to their training and experience, few clinicians who subscribe to the currently used principles of osseous surgery would accept this concept of molar buccal reduction. Therefore, the usual design for the buccal slope would be line D, since even line C would ordinarily be considered too flat for a proper slope. When one considers the amount of bone removed from the coronal height of the buccal aspect of the crater to the level of line D, it becomes frightening. This is supporting bone, and furthermore the buccal slope determines the amount of marginal bone to be removed.

Another consideration related to over treatment is the high incidence of mandibular molars with short root trunks. From the author’s clinical

practice it has been estimated that short root trunks represent 30% to 35% of mandibular molars. This figure may seem excessive at first; however, it will become more acceptable as radiographs and clinical material are studied. There is no statistical data to support or refute the estimated percentages of any of the root trunk types. The accuracy of the percentages for root types is not critical; it is primarily an academic issue. The critical factor is the clinician’s awareness of the root type prior to making surgical alterations. The buccal reduction of a medium crater of 3.0 to 4.0 mm in the presence of a short root trunk will predictably create reversed architecture. Since the percentage of short root trunks is high and clinicians are oriented to operating mandibular molar craters from the buccal side without concern for the root trunk dimension, it follows that many cases will terminate with reversed architecture, which is overtreatment.

Rapid Bone Destruction in Incipient Furcations Following Osteoplasty

Most therapists have not escaped the experience of having performed minor osteoplasty procedures involving in incipient furcation and then after a brief period of time noticing that rapid and extensive bone destruction had taken place in the interradicular area. This is commonly referred to as a "blowout" of the furca. It is an unsettling experience for both clinician and patient.

As this problem is explored, there are several factors that may be pertinent. The "blowouts" seen to involve mandibular molars and they are usually related to the buccal furcations. Lingual furcations, for some reason, have not been initially involved. Perhaps the most important observation indicates that the majority of mandibular molars associated with this problem have short root trunks. An example can be seen in Fig. 37a. The mandibular first and second molars had shallow depth craters and incipient furca invasions. The furcals received osteoplasty procedures in conjunction with the crator management. A 60 day postoperative result reveals extensive bone destruction on both molars (Fig. 37b).

It is important to observe the preoperative radiograph in Fig. 37a and the presence of short root trunks on both molars. In reviewing past records of incipient furca invasions with rapid bone loss in the furclas following osteoplasty, it is apparent that most had short root trunks.

Furcation Invasions

As stated previously, classic types of craters present a base from which guidelines can be established. The guidelines will need to be modified when there is significant pocket depth or furca invasion on the buccal surface of maxillary molars and from either or both sides of mandibular molars. Up to this point, the base of the crater has been related to the furca in an effort to avoid reversed architecture and complications related to the furca. Therefore, the emphasis has been placed on protecting the furca, but if the furca is already invaded, the objectives must be altered. In the presence of a furcation invasion, the base of the crater should be related to the bone level in the furca.

A classic furcation invasion is illustrated in Fig. 38, diagram A. In this situation, there is a greater discrepancy in the levels of the base of the crater and the height of bone in the furca. Since an advanced furcation invasion usually extends from the buccal to the lingual surface, prognosis is poor and will require meticulous maintenance care by the clinician and the patient.

An incipient furcation with a short root trunk and associated shallow crater is seen in Fig. 38, diagram B. Prognosis is often good for such teeth because the level of the furca and the base of the crater are similar. Radicular bone is removed to create continuity from the furca to the interdental area.

Another aspect of the furca dilemma is seen in Fig. 38, diagram C. An incipient furcation involvement is seen again, but now with a long root trunk in the presence of a crater. It is
readily obvious that the long root trunk places even the incipient furcation involvement considerably apical to the base of the interdental craters. The root surface dimension involved from the furca to the base of the craters has a mesiobuccal and a vertical component, and it is the vertical component that presents a problem. Since the mesiobuccal dimension of the root is minimal and the final bone contour established from the furca to the base of the crater is precipitous, the opportunity for gingival proliferation at the furca is certainly excellent. Regrowth of pocket depth will follow and a prognosis for such a furcation involvement is poor or guarded.

It is interesting that both diagrams B and C in Fig. 38 represent incipient furcations, but they have different prognoses due to the root trunk dimension. The potential for gingiva to proliferate coronally in the area of the furca is related to the relationship between the furca and the interdental bone height or the base of the crater. The greater the discrepancy between the two levels, the greater the potential for gingival proliferation.

A radiograph of incipient furca invasions is seen in Fig. 39a. The first molar radiographically appears to have a furca invasion, but the second molar seems to be free of any such involvement. The base of the crater between the molars is apical to the level of the furcals. A clinical view of this area is seen in Fig. 39b and both furcals do, in fact, have incipient furca involvements. The buccal interdental bone can be seen along with a medium crater. The interdental buccal bone is presently on the same level as the furcals and any reduction of the crater from the buccal will produce reversed architecture. The buccal bone may be thinned, but any of its height is to be avoided. Therefore, very little therapy is indicated on the buccal aspect of this particular situation.

Fig. 39a. Radiograph of mandibular molars. The interdental bone level between the molars appears apical to the levels of the furcations. Clinically, incipient furcation involvements were present.

Fig. 39b. Incipient furcation involvements are evident on both molars and a medium crater is present between the molars. The furca positions and the interradicular bone representing the buccal aspect of the crater are on similar levels. Any reduction of the buccal aspects of the crater will result in reversed architecture. The severity is in direct proportion to the amount of buccal reduction.
Positive Architecture

In 1950 Goldman focused attention on physiologic gingival contours by means of gingivoplasty, which was at that time a departure from common practice. Concerning gingival craters he stated that "the gingiva should be contoured in such a manner that the base of the crater becomes the crest of the papilla." There was no mention in this publication relative to the problems of bony craters. However, since the introduction of this soft tissue concept, many clinicians and teaching institutions have applied the soft tissue principle to include the bony crater. The application of the principle to bone is worthy of discussion because it relates to the crux of our current state in osseous surgery.

Positive architecture is a common term used by many advocates of osseous surgery. Scalloped and parabolic architecture are also widely used terms that have a similar interpretation to positive architecture. By definition these terms mean that the interdental bone height is conspicuously coronal to the radicular bone. Many lecturers and publications have expressed with considerable emphasis that the facial and lingual aspects of the crater should be removed to the extent that the base of the crater becomes the most coronal bone in the interdental area. This concept of crater management is frequently seen in publications in which the crater is depicted along with steep buccal and lingual slopes to eliminate the crater. This same philosophy has been expressed by stating that facial and lingual radicular bone should be removed so that it is more apical than the interdental bone. In addition to the above, some clinicians have emphasized that terminating osseous surgery with a flat architecture is a compromise in therapy. Furthermore, it has been said that shallow craters should be managed with a positive architecture.

A high percentage of proponents of osseous surgery are followers of the positive, scalloped, or parabolic architecture discipline. This type of architecture is established by first creating relatively steep slopes in the interdental bone that houses the crater. Marginal bone is removed according to the dictates of the buccal and lingual slopes. A review of the literature which refers to positive architecture indicates a near total absence of any reference to dimensions that are considered to be proper between the height of the marginal and interdental bone. There is also no reference to any anatomical variation which would influence or limit positive architecture. If a technique has no anatomical landmarks to act as "guides" or "stops", there can never be any consistency in communicating the technique. However, the key issue at stake is not the lack of dimensions or landmarks for the proper development of positive architecture. The real problem concerns the excessive removal of bone and the resulting complications.

In order to address the premise which advocates that terminating osseous surgery with a flat architecture is a compromise, several items should be discussed. It has probably been evident that the advocated bone architecture for molar areas, following surgical correction of the defects, has been basically flat with gradual slopes to the palate or lingual aspects. Some advocates of osseous surgery would no doubt find it difficult to accept this flat architecture premise. They would support their philosophy by stating that when the periodontium of a particular case has demonstrated susceptibility to periodontal disease, the opportunity for long-term postoperative health would be enhanced by creating a scalloped, sculptured bone architecture.

Since architecture and its influence on surgical therapy represents an important subject, various factors deserve thought and consideration. If a large number of extracted molars are examined, it will be evident that the mesial and distal cementoenamel junctions are relatively flat, with few having more than 1.0 mm of curvature. The literature and dental anatomy textbooks support this observation and also the fact that the interdental bone is a mirror image of the cementoenamel junction. Therefore, it is logical to assume that the buccolingual morphology of the interdental bone is relatively flat for most situations. It is also reasonable to suggest that most molar gingival architecture is flat to semiflat. It does not seem rational that the clinician possess the foresight to determine that certain periodontiums should receive a positive or idealistic bone architecture which would increase the periodontium's chances for survival.

Another factor that deserves proper consideration is the architecture of gingiva and bone when they are surgically placed in a recessed or more apical position. In most circumstances, the mesiodistal dimension of the interdental bone is increased as its height is altered or reduced. This is due to root morphol-
ogy and the relationship of adjacent roots that comprise the interdental area. As the mesiodistal distance increases, the bone and gingiva accept a flatter morphology. Therefore, a scalloped preoperative gingiva with 3.0 to 4.0 mm of interdental height might well accept a much flatter architecture, with perhaps 1.0 to 2.0 mm of interdental height following surgery. Again, it should be remembered that many periodontal patients have relatively flat gingival architecture in molar areas. Furthermore, many patients with flat gingival architecture have normal gingiva. There is no statistical data available to suggest that a scalloped architecture has a greater degree of health than a flat type. Unfortunately, we have come to believe that a thin, sped, undulated periodontium is the ideal and epitomizes health.

Converting a thick periodontium to a thin one by reducing thick buccal and lingual bone has long been a basic tenet of osseous surgery. Procedures designed for the thinning of thick bone is one issue and creating a sculptured positive architecture is a totally different matter. When a thick periodontium is thinned it represents osteoplasty and there is no sacrifice of supporting bone. However, when a flat periodontium is changed to a scalloped or positive type, it can only be done by osteotomy, which is the removal of supporting bone. It is common to hear the expression that a certain case was converted from a thick periodontium to a thin one with a positive architecture. These are two separate issues and they need to be identified as such. When a flat architecture is converted to a positive architecture there should be considerable thought given to the situation and, in general, there are few indications for such a procedure.

Reversed Architecture

The term reversed architecture is self-explanatory referring to gingival topography that is the opposite of the normal pattern. It exists when the interdental papilla is apical to the buccal and lingual marginal gingiva instead of coronal to it. In the early 1950s, buccal reversed architecture was routinely created on maxillary molars in an effort to reduce existing caries. In many instances, the craters were classic examples with shallow sulci in the radicular area. In the presence of good oral hygiene, the reversed gingival architecture in the area of the furca frequently developed an enlarged fibrinous interradicular papilla. This bulbous papilla is easily traumatized by the patient's oral hygiene, which perpetuates an iatrogenic problem. Bleeding upon slight provocation is common and gingivoplasty usually produces only temporary benefits. Within variable periods of time, these areas usually develop furca invasions. Therefore, it is reasonable to conclude that the therapeutic efforts may have hastened the loss of many molars.

Perhaps it is impossible to fully comprehend the problem of reversed architecture with only a vicarious relationship. The clinician must actually experience the problem of maintenance and treatment of this type of problem. Gingivoplasty will usually provide only a temporary improvement because the bone morphology is the real offender. Reversed architecture on single rooted teeth can sometimes be corrected, but there is no satisfactory solution to marked reversed architecture in molar areas.
Vertical Grooving

The literature on osseous surgery contains numerous references to vertical grooving and its role in the refinement of the procedure. There is little evidence to support its frequent use in the management of periodontal defects. Contours created by vertical grooving are not the same as contours seen in human skulls. Dry skulls with a pronounced scalloped architecture of the maxillary anterior bone frequently reveal prominent roots, thin radicular bone, and in general an undulating and sculptured pattern. However, there is a gradual diminishing of interdental bone height as the transition is made from anterior to posterior and there is also an undulating effect on the buccal bone of molar areas. More than 200® skulls have been examined and it was unusual to find any resemblance of vertical grooves in posterior areas. This should not be interpreted as condensation of the use of subtle interdental slits, which in effect would place the healed gingival papilla in a more protected interdental position.

Use of vertical grooving in the interdental posterior areas may cause irreversible damage. Deep grooving is contraindicated in the presence of some medium depth craters and practically all deep broad based craters. The buccal interdental bone representing the buccal aspect of the crater in such lesions is usually thin, and grooving in this area frequently causes the inadvertent reduction of the buccal aspect of the crater. The consequences are likely to be varying degrees of reversed architecture.

Discussion

A moment of truth comes to the clinician when, after his best efforts to instrument the root surfaces of 5.0 to 6.0 mm pockets, he reflects a flap, exposes the root surfaces, and is often struck with the presence of plaque, calculus, root imperfections, and aberrations that were previously masked by gingiva. The problems become particularly evident when they are viewed with magnifying loops. Then the various residual root problems will intimidate the best of clinicians. The more one reflects flaps and observes all the root related problems, the more convinced one becomes that closed curettage has a limited role in the management of well established periodontitis. Therefore, when the therapist is convinced that his best root instrumentation to remove calculus and plaque from the total dimension of the pocket is futile, he may possibly develop a keen interest in pursuing methods of pocket reduction. It is in this arena that osseous surgery can perform and the principal reason why so many clinical periodontists continue to use osseous surgery in their daily practice.

Clinical research and the practice of periodontics are intrinsically bound to each other. Obviously, they should have the common goal of attempting to provide a better service for the periodontal patient. It is inconceivable that the clinician can practice at his optimum without sufficient knowledge of current research information. Perhaps in past years the periodontist could function as both a reputable researcher and a respected clinician. Today, however, much of the current research has become too complex for the practicing periodontist to pursue with any degree of competency. On the other hand, current broad spectrum clinical procedures are technically too involved for the researcher to perform with a commendable degree of skill. Refinement and improvement of technical procedures such as root instrumentation, osseous surgery, bone regenerative procedures, bone grafts, suturing, and numerous other therapeutic related procedures will stem from serious clinicians. The literature will support this point of view.

Minimal skills are required to remove gross amounts of bone surrounding a tooth. A clinician with only a brief understanding of periodontics should be able to perform this type of surgery. It should be emphasized that the primary objective of osseous surgery is to remove the minimal amount of bone that will meet the needs of an adequate architectural form.

The recognition of specific bony defects, their relationship to contiguous anatomical structures, and the application of this information to clinical problems is a sine qua non in periodontal therapy. For various reasons, however, the application of anatomic factors seems difficult for clinicians to grasp. The three wall bony defect described by Pichard is a prime example. It has taken years for therapists to clinically comprehend his original description of the three wall lesion. They could verbalize Pichard’s description, but their knowledge could not be transferred to daily clinical situations. The anatomical landmarks outlined in this publication have been presented with the assistance of diagrams for purposes of explanation and clari-
cation. Most diagrams, unfortunately, have a common problem of oversimplification. The obvious anatomical factors projected in the diagrams are considerably more obscure in the patient's mouth. Effort and perseverance will be required for the application of the principles outlined in this primer.

Summary
Pocket reduction has long been an important issue to the practitioner of periodontics. The success rate of regenerative and bone grafting procedures presently seems to be limited to specific bony defects and the overwhelming majority of bony abstractions are seen as shallow and medium craters. These defects are best suited for osseous surgery if go. If pocket reduction are considered. The basic principles of osseous surgery can be effectively taught and communicated with anatomical landmarks acting as boundaries. This information coupled with a knowledge of normal bone topography will assist the clinician in the efficient and consistent management of bony craters. This anatomical information is basic to our understanding of conservative osseous surgery and it is with this thought that a primer for osseous surgery is presented.

References