Chapter 7 Periodontal Osseous Resective Surgery

INTRODUCTION

Successful treatment of periodontal disease can be achieved today through a number of surgical and nonsurgical procedures, each aiming to control infection and inflammation and reduce pocket depth. Periodontal surgery can still be considered a keystone in the treatment of periodontitis. Osseous resective surgery is defined as a means of changing the diseased tissue contour to reproduce a more physiologic anatomy. Knowledge of the pathogenetic mechanisms of the disease process and identification of the defect characteristics enable the clinician to select the appropriate surgical therapy to correct the deformity and establish a healthy environment.

The degree of destruction of periodontal tissues involving bone, periodontal ligament, cementum, and connective tissue depends on several factors such as type of bacteria, host response, teeth anatomy, hard and soft tissue biotypes, and so forth. Once the lesion has progressed apically, a discrepancy between the gingival margin and bone contour is established, resulting in a pocket. The characteristics of this pocket are determined by gingival biotype, morphology of the osseous crest, and teeth anatomy and location. As the inflammation caused by the periodonto-pathogens moves apically in the periodontal apparatus, a change in the anatomy of the zone takes place. If the bone is thick enough, a funnel-shaped defect is created while the surrounding bone not involved in the demineralization process maintains the gingival tissue in the same position. In the case of thin bone, such as buccal bone or interproximal bone between mandibular incisors, a horizontal pattern of resorption usually takes place, and depending on the soft tissue thickness, a recession or a suprabony pocket is formed.

INDICATIONS AND ENDPOINTS

The goal of osseous resective surgery is to establish minimal or physiologic probing depth and create a gingival contour compatible with good self-performed oral hygiene (Barrington, 1981). Even if regeneration of the lost periodontal apparatus is considered to be the ideal form of treatment, this can be successfully applied only to a limited number of defects according to their infraosseous depth and morphology. There is a clear indication in the literature that regenerative principles should be applied to those defects with an intra-osseous component greater than or equal to 4 mm. Therefore, osseous resection is indicated in a number of clinical situations whenever the infra-osseous defect depth is in the 3-mm range or whenever a one-wall defect is present (Ochsenbein, 1986).

Bone re-contouring should be carried out to achieve the so-called positive architecture. This term refers to the physiologic morphology of the alveolar bone that is located in a more coronal position interproximally compared to the radicular buccal and palatal/lingual aspect of the teeth (Figure 7.1). The bone contour follows the cementoenamel junction of the teeth and may be more or less concave, according to the tooth type and genetic biotype (Becker et al., 1997). Therefore, the alveolar crest architecture would have a more pronounced scalloping around incisors and canines, while that toward the molar region would progress in a more flat profile (Figure 7.2).

In a healthy condition, the gingival margin follows the bone architecture so that a consistency between the two entities can be recorded (Matherson, 1988). This is considered during surgical correction of osseous defects to avoid excessive or inappropriate remodelling of the osseous crest. Another field of application for osseous resective surgery is in the case of pre-prosthetic applications. Exposing sound tooth structure, re-establishing a biologic space between alveolar bone and the restoration margin, or correcting an un-esthetic gingival contour can be achieved through osseous resective surgery. In those instances the surgical approach is best known as a crown lengthening procedure (Ingber et al., 1977).

PHYSIOLOGIC AND PATHOLOGIC ALVEOLAR BONE ANATOMY

Unaltered alveolar bone morphology is characterized by the following conditions:

- The interproximal bone peaks are located at a more coronal position compared to the buccal or palatal bone. This is identified as a positive architecture. A negative architecture is considered whenever, due to the effect of periodontal disease, the position of the interdental bone is apical to the one of the buccal or palatal/lingual side. A flat type of architecture is identified whenever interproximal and buccal or palatal bone contour lie on the same line. This can be an effect of periodontal disease or the result of a surgical treatment if an ideal osseous recontouring cannot be achieved.

- The buccal or palatal/lingual bone architecture follows the cementoenamel junction (CEJ) of the related tooth. Therefore, the concavity may be more or less accentuated according to the tooth anatomy. The bone crest appears to be more scalloped at the single-rooted teeth compared to the molars, which present a more flat contour.
- The interproximal bone anatomy reflects the position and root anatomy of the proximal teeth. In the anterior areas, because of the reduced interproximal embrasure and the more or less conical anatomy of the root of the adjacent teeth, this morphology has a knife-edge contour. On the contrary, in the molar area the embrasure is wider and the roots have a more complex anatomy with concavity and convexity leading to a flatter morphology.

Figure 7.1. An example of positive architecture is shown in this human dry mandible. The buccal alveolar bone is apical to the interproximal crest. Courtesy of Dr. Hyman Smukler, Brookline, MA, USA.

These differences also have an impact from a histologic point of view. A thin knife edge interproximal area usually includes only cortical bone with minimal or no cancellous component (Figure 7.3). This is true, as demonstrated by Tal (1984), any time the distance between two adjacent roots is less than 3 mm. In this case, around 1 mm on each tooth side of the inter-radicular space is occupied by the periodontal ligament and only about 1 mm is left for the alveolar crest that would be made of only cortical bone. In a molar area the embrasure is usually wider and therefore the inter-radicular bone may include both cortical and cancellous bone compartments (Figure 7.4). These above-mentioned anatomical features play a significant role in the pathogenesis of an infra-osseous defect. The inflammatory process, in the case of a narrow interproximal space with a mainly cortical interdental bone, usually determines a horizontal pattern of resorption. Conversely, in the case of a wider embrasure, with thicker cortical and cancellous bone, an infra-osseous defect is more likely to occur. (Figure 7.5)

- The buccal bone is usually thinner than the corresponding palatal or lingual bone according to the biotype. Root prominence, such as in the case of canines or the mesio-buccal root of the first maxillary molars, may determine a further reduction of the bone thickness predisposing to buccal bone dehiscences and fenestrations. Eliot and Bowers (1963), studying human skulls, reported an incidence of bone defects of about 20%. Fenestrations were more frequent in the maxilla, whereas dehiscences occurred at a higher rate in the mandible. The occurrence of one of these defects during periodontal surgery may complicate the osseous recontouring or may determine a significant change in the treatment goals. (Figure 7.6)

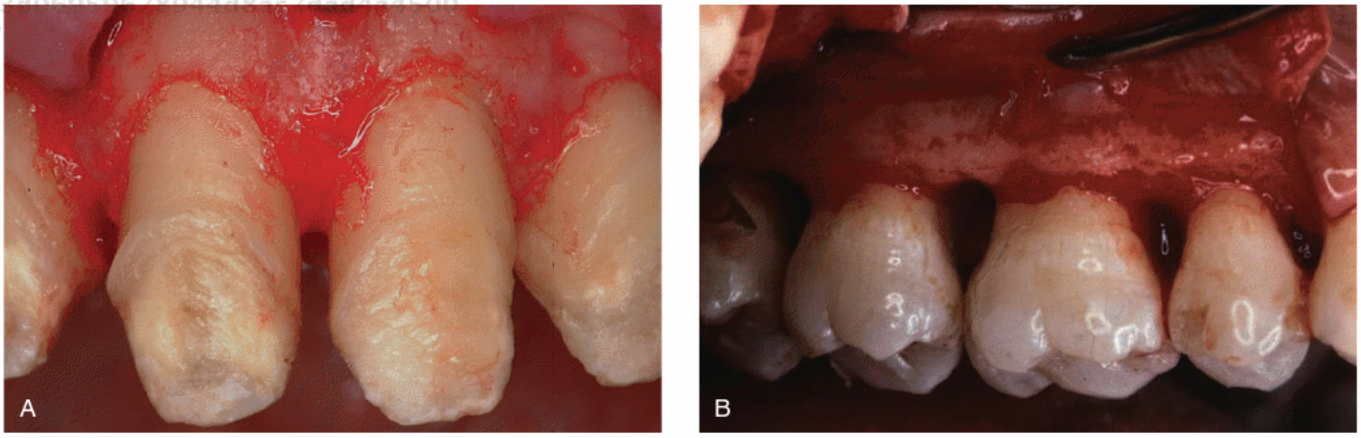

Figure 7.2. A, Surgical exposure of the alveolar crest around maxillary incisors during a crown lengthening procedure. Note how the bone architecture follows the CEJ outline, creating a scalloped morphology. B, A full-thickness flap of a maxillary posterior sextant for pocket elimination. The alveolar crest at the molar area runs with minimal scalloping according to the CEJ morphology.

Figure 7.3. Histologic specimen from a monkey (*Macaca fascicularis*) showing the interproximal bone septum between the canine and incisor. The coronal part of the crest consists of only cortical bone, while cancellous bone becomes evident toward the middle third of the septum. Courtesy of Dr. Morris Ruben, Boston, MA, USA.

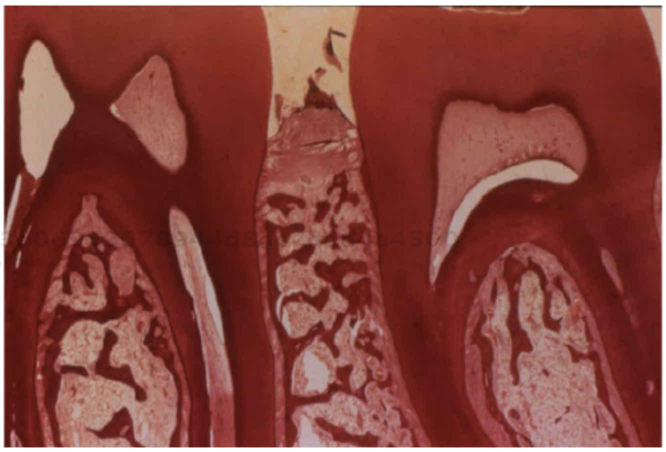

Figure 7.4. Histologic view of a block section taken from a non-human primate at the molar area. The interproximal distance is greater than 3 mm and cortical and cancellous bone are well represented. Courtesy of Dr. Morris Ruben, Boston, MA, USA.

Figure 7.5. A large semi-circumferential three-wall defect around the mesio-lingual aspect of a mandibular first molar is exposed during surgery. The thickness of the lingual cortex and the inter-radicular distance account for the defect morphology.

Figure 7.6. After flap elevation for pocket elimination, a dehiscence at the disto-buccal roots of the first molar has occurred. This finding greatly affects treatment strategy and approach. Courtesy of Dr. Alessandro Crea, Viterbo, Italy.

PRINCIPLES

The principles of osseous resective surgery, as it is conceived today, date back to Schluger (1949) and Friedman (1955). Those authors reported the need for eliminating osseous defects so that a consistency between osseous topography and gingival tissue could be re-established, but at a more apical level. According to the *Glossary of Periodontal Terms*, osseous resective surgery includes two different steps: (1) osteoplasty, the reshaping of the alveolar process to achieve a more physiologic form without removing supporting bone, and (2) ostectomy, the excision of bone or portion of a bone that is part of a periodontal defect and includes removal of supporting bone.

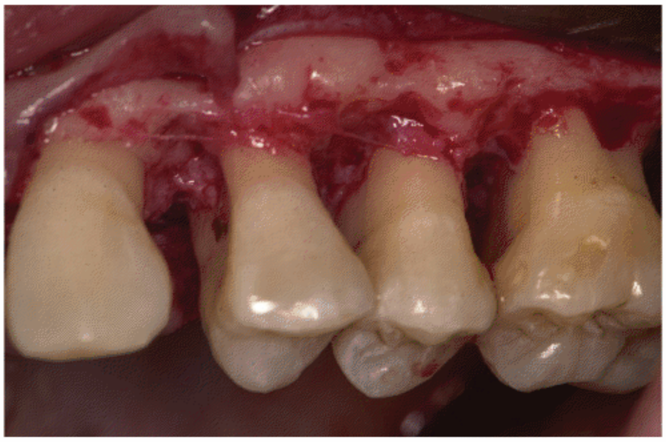

Figure 7.7. A thick buccal bony ledge can be observed after a full-thickness flap is raised. Bony ledges are often accompanied by infra-osseous defects and craters. Their elimination includes a generous osteoplasty to achieve a physiologic osseous anatomy.

According to Friedman (1955) osteoplasty, is indicated in the case of buccal and/or interpoximal thick bony ledges (Figure 7.7), whereas ostectomy should be used to correct shallow interproximal defects such as craters and hemisepti. This resective approach has several limitations and side effects, and often the application of these principles may determine extraction of involved teeth or an unacceptable esthetic result for the patient. Those limitations have been discussed by Siebert (1976), who reported that the main side effect was the loss of attachment induced by the surgery. He also listed a series of factors that should be taken into account before selecting ostectomy as the surgical treatment modality. Those factors include the length and shape of the roots, location and dimension of the defect, width of investing bone, root prominence, and relationship between the intrabony defects and the adjacent teeth or anatomic structures (maxillary sinus, alveolar nerve, etc). For these reasons, osseous resection underwent a series of modifications through the years, aiming to reduce the amount of bone removal during surgery and thus decreasing the resulting attachment loss.

It should be stressed that osseous resective surgery must be used cautiously whenever an area with esthetic concern is involved in the surgical plan. To simplify the surgical approach to esthetic areas, the key to deciding whether or not to use resective surgery is related to the presence of or a need for a prosthetic involvement. In those cases, osseous resection may be ideal. When there is no prosthetic commitment, only limited and selected cases, including patients with a low smile line and with low esthetic expectations, may be appropriate for this technique (Figure 7.8, Tables 7.1, 7.2).

Table 7.1 Indications and contraindications to the surgical therapy in the case of anterior areas with no prosthetic involvement.

Therapy	Indications	Notes
Non-surgical Therapy (SRP)	√ PPD > 4 mm √ Horizontal defects	Attention to thin biotypes for recessions
Access Surgery 1. Labial curtain 2. Papilla preservation	√ PPD > 6 mm √ Vertical defects √ Palatal defects	Attention to the high smile
Osseous resective surgery	√ Rarely √ Low lip line √ Low esthetic expectation	Attention to the post-op teeth sensitivity

Table 7.2 Indications and contraindications to the surgical therapy in the case of anterior areas with prosthetic involvement.

Therapy	Indications	Notes
Non-surgical Therapy (SRP)	√ PPD 4–5 mm √ Horizontal defects	Attention to thin biotypes for recessions
Access Surgery 1. Labial curtain 2. Papilla preservation	√ Palatal defects √ Severe buccal recessions and extremely long crowns	No if infrabony defect > 4 mm Attention to the high smile
Osseous resective surgery	√ PPD > 4 mm √ Medium and shallow intrabony defects	Att.: Crown-to-root ratio Att: Clinical crown length

TECHNIQUE

If osseous resective surgery is selected as a treatment option, several steps should be followed to correctly apply the technique.

Flap Design

Osseous resective surgery is usually coupled with an apical position of the flap. A para-marginal or sub-marginal incision using a 15 or 15C blade is carried out according to the soft tissue characteristics. A split or combined full-split flap may be used to expose the underlying alveolar bone. Releasing incisions may be necessary to gain better surgical visibility or to easily position the flap at the end of the surgery. Vertical incisions should always be carried out beyond the muco-

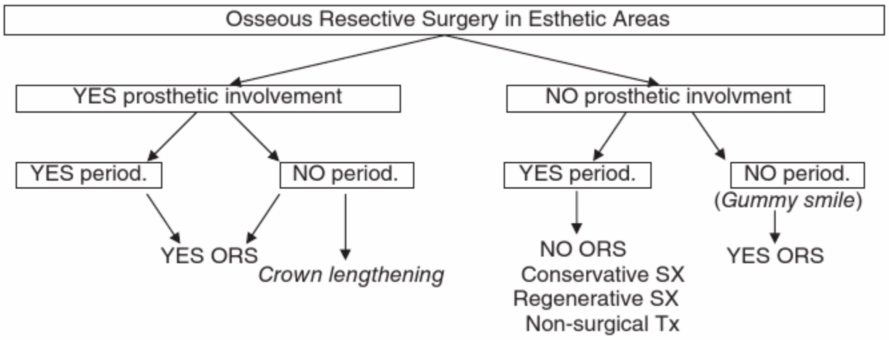

Figure 7.8. Strategic use of resective surgery according to the presence of prosthetic involvement and the diagnosis of periodontal disease.

gingival line buccally and lingually, while the palatal aspect should be extended far enough to allow flap mobilization. The main concern in designing the flap is to provide an adequate vascular supply to the margin of the mobilized flap. Therefore, the apical portion of the flap must be wider than the coronal one and should include the major vessel of the area. For this reason vertical releasing incisions should go by the following general principles: (a) must be bevelled, (b) must be divergent toward the apex, (c) should be placed at the mesial and/or distal line angle of the last tooth included in the surgical area, and (d) radicular and interpoximal areas must be avoided due to the major blood supply.

Degranulation and Root Debridement

Once the flap is reflected, degranulation of the soft tissue must be done with surgical curettes (Goldman-Fox n.2, n.3; Barnhardt n. 1/2, etc.) and with sonic/ultrasonic and hand scalers. Once the degranulation is completed and the defect can be identified thoroughly, the root surfaces should be cleaned and planed. Root preparation must be carried out with great care because it greatly influences the type of healing that will take place at the end of the surgical procedures. Polson and Caton described the factors influencing periodontal repair in a primate model (Polson and Caton, 1982). They showed that root surface alterations and contamination inhibit new connective tissue attachment and they stressed the importance of a complete root surface debridement for periodontal healing.

Identification and Measurement of the Defect

Once the surgical field is cleaned, the defect is measured and identified. This is critical in determining the amount of ostectomy and osteoplasty that is indicated. In addition, location of the furcation entrance, root trunk length, or anatomical characteristics of the surgical area must be identified.

Osteoplasty/Ostectomy

The first step is reducing the interpoximal bone thickness. This procedure, called grooving, determines the amount of osteoplasty that is needed at the radicular bone. In the case of a very thin buccal or palatal/lingual bone, a minimal or no osteoplasty is required. In other instances, a thick bony ledge may be present, requiring aggressive bone re-contouring. This is usually done with diamond coarse or carbide round burs mounted on a hand piece or a high speed hand piece under abundant water cooling irrigation (Figure 7.9). In the case of a bony ledge, a thin cortical layer may be encountered and if care is not taken during the osteoplasty a deep groove into the ledge may be produced as the bur drops into the cancellous bone once the resistance offered by the cortical bone is gone.

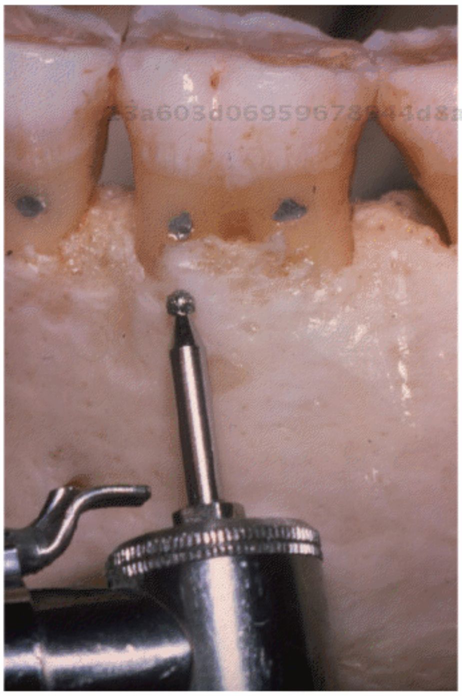

Figure 7.9. A diamond coarse round bur (Brassler, USA) can be used to perform osteoplasty. Due to its moderate cutting ability, compared to the carbide bur, it may be indicated whenever minimal osteoplasty must be done.

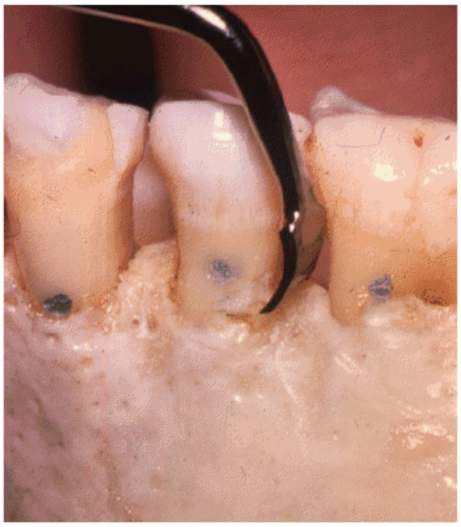

Figure 7.10. A back action (Rhodes 36–37 Hu-friedy, USA) is used in a dry mandible to demonstrate how to perform fine ostectomy. The blade of the instrument is placed on the radicular bone and moved backwards toward the root to eliminate the supporting bone involved in the defect.

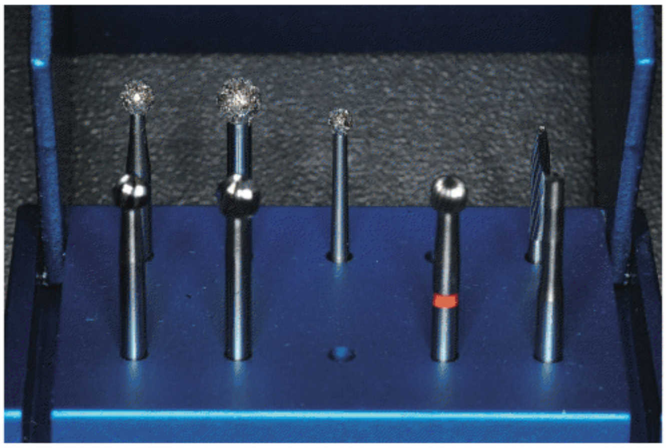

Figure 7.11. An osseous resective surgery bur kit (Brassler, USA), including different sized round burs made of diamond coarse and carbide. The end-cutting bur 957c-H207C is used to remove supporting bone around the tooth without damaging the root surface.

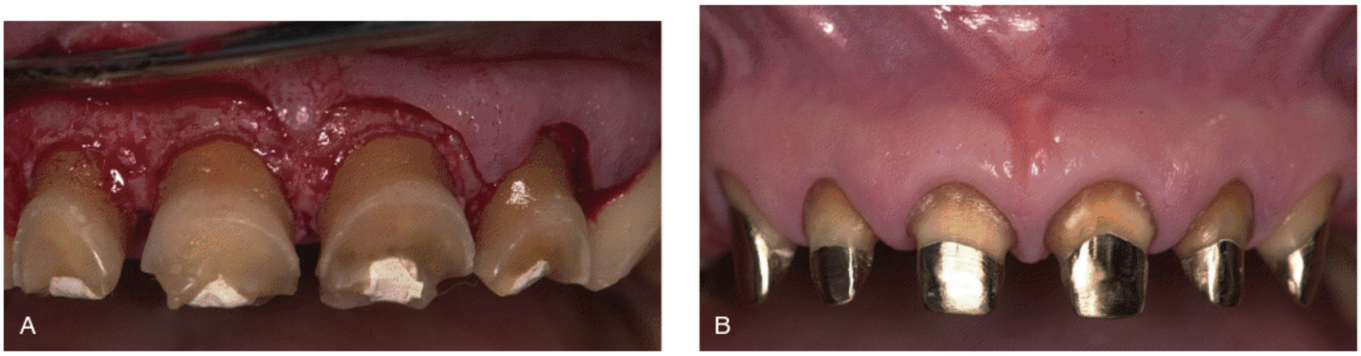

Figure 7.12. A, It may be useful to create a bone ledge in the esthetic area. In this case a crown lengthening has been done and a certain degree of crestal thickness has been intentionally achieved. B, Six months after surgery and before final prosthetic delivery. It is observable that the thickness of crest contributed to the creation of a thick and firm gingival unit.

As soon as the grooving is accomplished, a radicular blending must be done to produce a smooth and blended surface (also known as a sluice-way profile) to enhance flap adaptation. During this step a careful evaluation of root position and anatomy will reduce the risk of causing any fenestration or dehiscence. At this point ostectomy comes into play. One wall, craters, or other defects should be removed and interpoximal and radicular bone designed to achieve a positive architecture. Radicular bone removal is usually carried out with hand instruments. The Ochsenbain chisel (n.1 and 2) and back baction chisel (Rhodes 36–37) (Figure 7.10) are the most popular instruments used for this purpose. Rotary instruments also may be used, but great care must be taken so as to not damage the root while carrying out the ostectomy. Special burs with only an end-cutting head have been designed for this purpose and may be very useful in the interpoximal areas (Figure 7.11).

The more bone that is removed from the radicular or interpoximal areas, the thicker the alveolar margin; this phenomenon is known as ledging. The desired newly established alveolar bone morphology should have a knife-edged profile to allow better flap adaptation and reduce the chance of pocket re-formation. However, there are instances, such as during crown lengthening, in which a certain degree of margin thickness (ledge) is desirable to support soft tissue stability (Figure 7.12).

The last surgical step is the correction of the interdental area. The presence of a crater or a one-wall defect may be managed according to the location and anatomy of the tooth, either by a complete flattening of the crest or by a palatal/lingual approach. This can be done initially with a round bur and completed with bone files (Sugerman file, Kramer and Nevins, etc.). In addition, the removal of the so-called widow's peak is critical. These peaks consist of residual bone left at the facial and palatal/lingual line angles of the teeth. During the healing process, the persistence of these formations may lead to a soft tissue bridging with a re-pocketing of the area. Their elimination is achieved with hand chisels (Wiedelstadt n.1 and n.2) that are run into the interdental area against the radicular surfaces.

Another important factor that influences the ability to achieve a positive architecture is the amount of the residual attachment apparatus. Performing osseous resection to eliminate pockets and defects should not jeopardize tooth stability. The length and anatomy of the roots and evaluation of the residual periodontal support help determine whether osseous resection may be the treatment of choice. The amount of bone that is removed during osseous surgery may vary according to the defect characteristics, the bone architecture, and the teeth morphology. Selipsky (1976) showed that an average of 0.6 mm of support per tooth may be removed with osseous resective surgery. He concluded that although a significant amount of the total bone had to be removed, only a minimal amount of the removed portion would be the supporting apparatus. The increase of mobility following the surgical therapy is transitory and returns to the pre-operative level in about 12 months.

Suturing

Once the osseous re-contour is completed the flap is placed apical to the pre-operative margin. Its position may be apical to or at the osseous crest. In the first case, a small portion of exposed bone, with or without its periosteum, is left exposed. A vertical or horizontal periosteal mattress suture may be used to hold the flap in position; the sutures may be interrupted or continuous. The use of sling sutures is also recommended any time the lingual/palatal or buccal flap must be placed at a different level. A periodontal dressing may or may not be used according to the operator's preference. In the authors' experience it seems that periodontal eugenol-free dressing (Coe-pack) may be indicated any time the flap is positioned apical to the osseous crest to improve patient comfort during healing and reduce the risk for flap displacement during healing. However, it is important to remember that the use of a periodontal dressing may delay the healing process and therefore routine use is no longer justified.

MODIFICATIONS TO THE ORIGINAL SURGICAL APPROACH

Palatal Approach

Ochsenbein and Bohannan (1963) were the first to introduce a modification of the original protocols, by describing the palatal approach. This approach was based on the observation that, due to teeth location and alveolar bone anatomy, infraosseous defects in the maxillary arch were located mainly interproximally and palatally. The palatal approach has several advantages: (a) the presence of an abundant amount of keratinized tissue on the palatal side, (b) an increased thickness of the alveolar bone compared to the buccal aspect, (c) a wider embrasure area between the molars, facilitating the surgical access, and (d) the cleansing effect of the tongue in the post-operative period.

By using this approach a palatally inclined ramp is created with minimal ostectomy. The majority of the osteoplasty and ostectomy are carried out from the palatal aspect and only minimal osseous contour is done buccally, preserving furcation entrance integrity in the molars and reducing the amount of root exposure in esthetically sensitive areas. In 1964, the same authors classified the interproximal defects (craters) in four different entities. Class I defect was characterized by a 2-mm to 3-mm deep component with thick facial and palatal walls; Class II was 4 mm to 5 mm deep with thin facial and palatal walls; Class III more than 6 mm deep with a sharp drop from the walls to a flat base, and Class IV, the least common situation, was characterized by a crater with a variable depth but extremely thin buccal and palatal walls. The authors associated a treatment option with each defect so that Class I could be managed only with palatal ramping, while Class II and III should be approached with both buccal and palatal ramping, and treatment of Class IV, although very unfavorable, included the elimination of buccal and palatal walls.

Lingual Approach

The same concept used in the maxilla was later introduced for the mandible. Tibbets et al. (1976) reported on how the mandibular molars and premolars should be approached from the lingual aspect. The rationale for this lies in the observation that molars and premolars have a lingual inclination (Wilson's curve around 29 degrees for the molars and 9 degrees for the premolars) so that the entrance of the lingual furcation is located at a more apical position compared to the buccal one. Furthermore, the lingual bone is thicker compared to the buccal (Figure 7.13) and there is always an adequate amount of keratinized tissue on this side. As for the palatal approach, this technique should be used to minimize the amount of ostectomy carried out in the buccal area, preserving the furcation integrity and reducing the total amount of attachment loss (Figure 7.14 a-b).

Fiber Retention Osseous Resective Surgery

Another and more recent modification of the osseous resective surgical technique has been presented by Carnevale (2007). This technique is based on the concept that supracrestal fibers inserted into the root cementum are always present coronal to the alveolar crest, both in diseased and healthy situations (Gargiulo et al., 1961; Carnevale et al., 1985). Therefore, it seems reasonable from a biological and clinical standpoint that preservation of those fibers during surgery may have two effects: (a) relocating the deepest portion of the defect at a more coronal position, and (b) reducing the amount of ostectomy required to eliminate the defect. In other words, the presence of a connective tissue attachment coronal to the crest determines a coronal shift of the apical component of the osseous defect.

Figure 7.13. Photograph of a dry human mandible showing the alveolar crest after removal of a first molar. The buccal bone is a very thin lamina compared to the lingual crest. Removal of lingual bone to correct a periodontal defect is preferred to prevent furcation exposure and severe buccal dehiscence.

The technique includes a split thinned flap and the careful removal of the soft tissue using a blade or an interproximal knife (Goldman-Fox n.11, Orban 5/6, Buck 1/2). This sharp dissection is followed by the identification of the residual attachment apparatus within the bone defect using a periodontal probe. The non-attached soft tissue is then removed and resection of the osseous crest is carried out. At the end of the alveolar bone re-contouring, only bone with attached fibers should be left around the tooth. This technique has been proven to be effective in reducing and maintaining probing depth within the normal range. Carnevale et al. (1991) reported on 304 periodontally compromised patients treated with the fiber retention osseous resective surgery who were followed for three to 17 years. The majority of the patients (86%) belonged to ADA case types 3 and 4. Patients were further divided into three groups according to the length of the follow-up period. Ninety-two patients were followed for 11.3 years. At the end of the study only 147 out of 8,572 sites were deeper than 4 mm (1.72% of the total sites), demonstrating a remarkable long-term stability of the results achieved at the completion of active therapy.

Data on teeth extraction also have been reported by the authors. It is significant that the majority of the teeth (576, that is, 7.5% of the total sample) were extracted during active treatment. Most of these teeth (63.7%) belonged to patients falling in the ADA case type 4 category, and the main reason for their loss was advance periodontal breakdown. During supportive therapy, however, the incidence of teeth extraction was dramatically reduced (67 teeth; 0.9% of the total sample) and limited to a subgroup of 50 patients. These results confirmed the effectiveness of this technique in treating and controlling advanced periodontal disease.

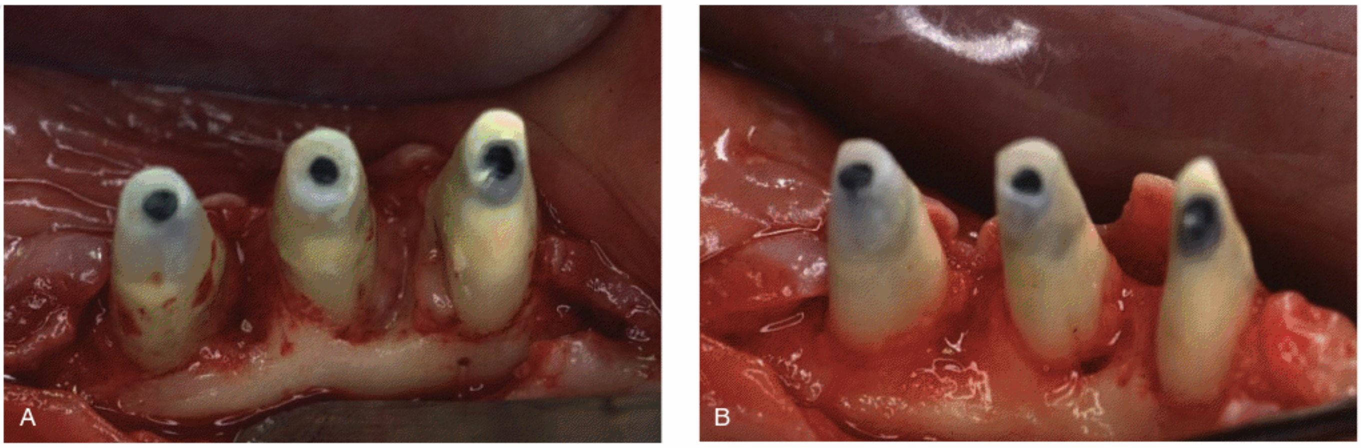

Figure 7.14. A, Craters and combined infrabony defect less than 3 mm deep lingually to prosthetic abutments. Lingual osteoplasty and minimal ostectomy are indicated to manage this defect. B, The result after osseous re-contouring and tooth preparation. No defects remain.

Furthermore, this technique should be considered a very reliable option in the case of complex perio-prosthetic case involvement.

SOFT TISSUE MANAGEMENT

The soft tissue component must be managed during the osseous surgery. Positioning the gingival margin apical to the pre-operative level is recommended any time elimination of the defect is indicated. This can be done in several ways according to the soft tissue biotype and osseous determinants.

Buccal/Facial Flap

Whenever an adequate band of keratinized tissue is present a sub-marginal scalloped incision may be outlined about 1 mm to 2 mm apical to the gingival margin or as deep as the required probing depth (Figure 7.15). A full-thickness thinned flap up the mucogingival line followed by a partial dissection or a complete partial-thickness flap may be elevated to gain access to the underlying bone. In the case of inadequate or minimal keratinized gingiva an intra-sulcular incision is preferred to preserve as much attached gingiva as possible. In the case of a very thin biotype a mucoperiosteal flap is preferred because the chance of flap perforation and necrosis may increase (Wood et al., 1972). Once the flap is elevated and osseous recontouring is performed, the mobility of the flap should be tested so that a passive positioning is obtained at or apical to the newly recontoured alveolar crest. As previously described, if vertical releasing incisions are indicated to freely move the flap, these should be extended into the alveolar mucosa.

Palatal Flap

A different approach is required on the palatal side because the gingiva in this area is completely keratinized and cannot be moved in an apico-coronal position. This approach, best known as palatal thinned flap, is used any time pocket reduction or elimination is required. The primary scalloped incision should be outlined according to the probing depth and following the anatomy of the teeth involved in the surgical area. For instance, the primary incision around a second premolar is more concave compared to that around a first molar. Another factor that influences flap design is root anatomy and morphology. As the defect moves apically, the size of the roots narrows. So in the case of a deep probing around the palatal root of a maxillary first molar, the scalloping should be calibrated to the root morphology rather than the mesio-distal dimension of the clinical crown. It is therefore root morphology that dictates the incision outline, rather than clinical crown anatomy. In addition, tooth position and consequently root direction must be considered in the surgical planning. Most of the time palatal roots of maxillary first and second molars have a disto-palatal direction. This must be considered in the flap design.

The palatal vault is another important anatomic issue for the thinned palatal flap. In the case of a high vault palate the incision may correspond to the probing depth, while in the case of a flat vault it should be outlined close to the gingival margin. This is mainly due to the presence of the greater palatal artery that runs into the soft tissue at a distance from the CEJ of the molars that varies according to the vault extension (Reiser et al., 1996).

Figure 7.15. A, Pre-surgical probing for crown lengthening. Surgical incisions are planned according to probing depth, toothy and root anatomy, and amount of keratinized tissue. B, In this case the abundance of keratinized tissue allows the outline of a submarginal scalloped full-thickness flap. Surgical papillae are created interproximally and facial to the furcation entrance to protect this area during healing.

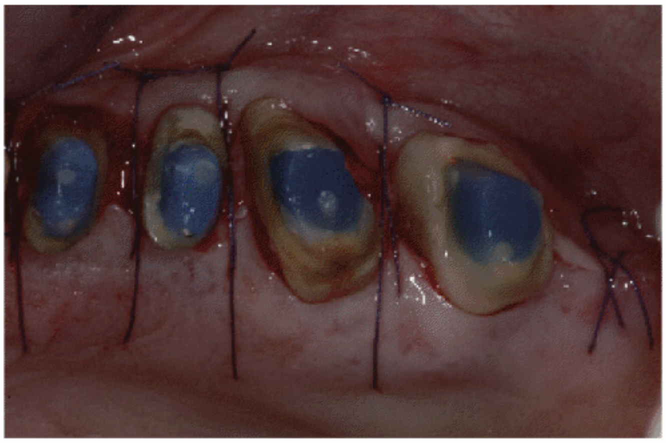

Figure 7.16. If properly outlined, a palatal thinned flap will drop on the re-contoured alveolar crest following the root anatomy. Minimal or no trimming should be required if proper tissue incisions are made. The picture shows a passive adaptation of a thinned flap. Note how the primary incisions have been designed according to the root position and anatomy.

A thinned flap is indicated to reduce the soft tissue component and achieve a pocket reduction with a better flap adaptation. The final crest morphology should be estimated during flap incisions so that minimal trimming of the flap is needed at the end of the surgery (Figure 7.16). A bone sounding under anaesthesia is required to determine the pre-operative bone contour. The periodontal probe is run into the palatal tissue until it stops, so that the thickness of the gingiva may be estimated.

The presence of an exostosis or osseous defect also may be recorded. This information will help the operator to create an evenly thinned flap along its entire extension. An interproximal thickening of the flap may determine poor tissue adaptation at the radicular aspect of the bone, thus creating an anatomical dead space that may result in a sloughing of the marginal tissue.

Remember that flap design and osseous anatomy are by far more crucial than the suturing technique in achieving passive flap adaptation. However, care must be taken during suturing to hold the flap in the proper position.

EFFECT OF SURGERY ON THE ALVEOLAR BONE

Flap elevation with or without bone reshaping determines a certain degree of crestal bone remodelling, leading to a loss of bone ranging from 0 mm to 0.8 mm (Donnenfeld et al., 1964). Studying the amount of post-surgical bone remodelling in a human model, Moghaddas and Stahl (1980) reported that the net bone loss at six months after osseous surgery combined with a full-thickness flap varied according to the location. Crestal bone loss averaged 0.23 mm in the interproximal space, 0.55 mm at the radicular aspect, and 0.88 mm in the furcation region of a molar. In their study the three months' data did not reach any statistically significant difference from the six months' data.

Another interesting finding of this work was that no correlation could be made between the amount of resection and the degree of remodelling. During a re-entry procedure, Donnenfeld and co-workers (1970) measured the amount of bone remodelling that took place in three patients undergoing osseous resective procedures both immediately after surgery and at six months. They reported an average of 0.6 mm of bone loss interproximally and 1 mm at the radicular location. Another study (Smith et al., 1980) described the bone loss after osseous resective surgery only through a bone sounding procedure at six months. They found 0.2 mm of radicular bone loss and 0.3 mm of interproximal bone loss. Pennell and co-workers (1967) described in a landmark paper the pattern of wound healing obtained from 34 teeth from 20 patients treated with a full-thickness flap followed by osteoplasty on 5 mm of marginal bone and ostectomy at the first mm of crestal bone. The post surgical observation period ranged from 14 to 545 days and they reported an average bone crest resorption of 0.54 mm. The majority of the teeth (82%) showed less than 1 mm of resorption, while severe bone loss (more than 3 mm) was recorded in only two cases.

Histologic Effect of Osseous Surgery

The best histologic evidence on the effect of resective procedures on the alveolar crest are reported by Wilderman et al. (1970). The sample included 23 block sections of teeth that underwent a mucoperiosteal flap followed by osteoplasty in the first 5 mm of alveolar bone and 1 mm of crestal bone reduction. The effect of bone surgery varies according to the nature of the alveolar bone. Superficial bone necrosis with intense osteoclastic activity was a common finding. In the case of a thin alveolar bone, resorption took place at the periodontal ligament side, while when a thick bone was found, the osteoclastic activity started within the marrow spaces toward the periosteal side. Osteoblastic activity reached its peak after 21 days, and after six months very little additional bone remodelling could be detected.

Interestingly, the mean loss of bone was 0.8 mm in the case of a thick alveolar crest, while it reached 3.1 mm in the case of a thin crest. This may be due to the different intrinsic healing potential of different bone anatomy. Thick cancellous bone holds better healing potential compared to thin cortical bone. Therefore, great attention must be paid to the quality of the bone during osseous surgery because the knowledge of these characteristics may be of great importance in determining the final surgical result.

EVIDENCE-BASED OUTCOMES

In the past 50 years a number of studies comparing different treatment approaches to periodontal pockets have been published. It is worth noticing that different conclusions may be drawn from the results presented with a certain degree of discrepancy. Evidence-based dentistry, as it is established today, is a very important tool for gaining a better understanding of the limitations and benefits of different treatment options. However, ideal studies fulfilling all of the requisites for the highest scientific evidence have yet to be performed. This chapter attempts to summarize the results of some of the most representative studies to give the reader some indications that may be useful in a clinical setting. A more in-depth and precise examination of the literature on this topic is suggested to gain a broader understanding of each of the studies quoted.

Osseous resective surgery has been studied alone and compared with other surgical and nonsurgical techniques in several longitudinal studies. Most of the studies reported on short-term results, while only a few extended to a five-year follow-up. Here we discuss only those studies with at least five years of follow-up. Although there are some differences, the layout of these studies is somewhat similar as different modalities of treatment have been tested in a split mouth design. The treatments rendered were osseous resective surgery with apical positioning of the flap, modified Widman flap surgery, and scaling and root planing. The results have been analyzed according to the initial probing depth. Three depth categories have been identified: 1 mm to 3 mm, 4 mm to 6 mm, and greater than 7 mm.

Knowles and co-workers (1979) treated 72 patients and found that while in a 1-mm to 3-mm depth there was a slight loss of attachment with all of the treatment modalities (thus demonstrating that there is no indication for any kind of treatment in a shallow pocket), for the 4 mm to 6 mm category osseous resective surgery achieved greater pocket depth reduction compared to scaling and root planing but similar results compared to Widman flap surgery. Interestingly, in this depth category all three modalities determined the same amount of attachment level gain. For the greater than 7 mm pockets, all of the treatments reduced the probing depth, but the Widman flap achieved a more significant reduction and a greater gain of attachment compared to the other two.

Ramfjord et al., in 1987, published a second study with a five-year follow-up. The general conclusions were similar to those previously reported except for the greater than 7 mm pockets. In this category the probing depth reduction, although greater compared to the other probing categories, did not show any significant difference in any of the three therapies (ORS 3.53 mm, MWF 3.13 mm, SRP 2.92 mm). This finding was also true for the attachment level gain; none of the treatments was superior to the others. Comparing the results of the one year of maintenance with the final examination at five years, it is notable that some periodontal deterioration took place in most of the patients. Although no statistically significant differences could be reported between the treatments in terms of probing depth reduction and gain of attachment, the incidence of loosing sites was twice in the Widman flap and scaling-treated quadrants compared to the resective surgery quadrants. It is also noteworthy that no molar furcations were included in this study.

In a similar study, Kaldahl and co-workers (1996) reported on 72 patients who were followed for more than five years. Osseous resective surgery was able to produce a greater probing depth reduction compared to Widman flap surgery and scaling and root planing during the entire study in the 5 mm to 6 mm pocket category (−1.85 mm for ORS, −1.48 for MWF, −1.52 for SRP). In terms of attachment level gain, osseous resective surgery had the least gain, 0.44 mm, while modified Widman flap surgery (0.60 mm) and scaling and root planing (0.90 mm) showed the greatest performance. In the greater than 7 mm pocket category, osseous resection was the most efficacious treatment in probing reduction (3.38 mm) compared to the other two (MWF 3.09 mm, SRP 2.88 mm). No statistically significant difference could be found in terms of clinical attachment gain between the three therapies at five years (ORS 1.83 mm, MWF 2.07 mm, SRP 1.88 mm).

Several considerations should be made before drawing a definitive conclusion from these studies. Probing depth alone does not reflect the anatomy and morphology of the underlying bony defect, so a deeper or shallower intrabony defect associated with the same probing depth may respond differently to the same treatment modality. The split mouth design may carry an innate bias related to the effect that one treatment may have on the others over the long term. Also, clear endpoints in the performance of osseous surgery have not been stated in any of the studies except those from the Nebraska group (Kaldahl et al., 1996). In this study the achievement of a positive architecture led to the extraction of several teeth and roots during surgery. This is clearly in contrast to other studies in which no mention of root resection or extraction was reported (Knowles et al., 1979; Ramfjord et al., 1987). This may be considered a major limitation in defining the effect of a specific treatment modality.

Another interesting point is the fact that attachment loosing sites appeared to have a higher incidence in those quadrants not treated with osseous resection. Usually the statistical comparison between treatments that has been reported has been based on the mean changes. Now if the number of attachment loosing sites is relatively small, it may be overshadowed by the majority of the stable sites. However, a site analysis may bring up differences that may be significant in the clinical setting. Therefore, the fact that patients treated with osseous resective procedures have a low incidence of attachment loosing sites (Kalkwarf et al., 1988; Kaldhal et al., 1996; Carnevale et al., 2007) may be very important in the case of perio-prosthetic rehabilitation in which disease recurrence may determine prosthetic failure.

A possible explanation for this stability of the apical positioning of the flap has been reported as a major contributor. Several studies (Mombelli et al., 1995; Levy et al., 2002) have shown that the apical displacement of the gingival margin exposing the previously contaminated root determines the formation of a new dento-gingival unit apical to the diseased cementum. This may also determine a positive shift of the microflora by modifying the existing habitat (Levy et al., 2002) and reduce the chance for micro-organisms (that have been dormant in the dentinal tubuli) to inhabit the newly formed shallow sulcus (Adriaens et al., 1988).

Treatment of Furcated Molars with Resective Techniques

Furcation lesions traditionally have been seen as a major challenge for periodontists and restorative dentists. Complicated root anatomy combined with limited access to the area due to teeth location have been cited for the poor prognosis of those areas. Furcation anatomy presents several characteristics that must be known before continuing with their treatment. Furcation entrance size, root trunk length, root concavities, and dome morphology all contributes to make treatment of furcation involvement a difficult task.

Classification of Furcation Involvement

Once a furcation is periodontally involved different treatment options may be contemplated in relation to the degree of involvement. A furcation lesion may be detected using a dedicated curved probe (Nabers probe) with color marking every 3 mm. Hamp et al. (1975) categorized furcation defects according to the degree of horizontal probing. Three different classes of severity were identified: Class I, when the probing was in the 3 mm range; Class II, if the probing was greater than 3 mm but not passing through the furcation; and Class III, if a through and through lesion was detectable. Tarnow and Fletcher (1984) added to the Hamp classification the evaluation of the vertical probing, identifying three different categories: Subclass A, 1 mm to 3 mm; Subclass B, 4 mm to 6 mm; and Subclass C, greater than 6 mm. According to the authors, this may help clinicians to improve treatment choices and predictability.

Ability to Remove Calculus

Furcation is a critical area for cleaning. Caffesse and coworkers (1986) showed that even with an open approach it was very difficult to achieve complete removal of the calculus from an involved furcation area. Matia et al. (1987), using a surgical approach, was able to remove calculus from only seven out of the 26 treated furcation surfaces. These difficulties in achieving a satisfactory result are determined mainly by the complicated anatomy of the area.

Molar Root Anatomy

Bower (1979) and Gher and Vernino (1980), analyzing extracted maxillary and mandibular molars, reported that the furcation aspect of mandibular molars presents a concavity up to 1 mm deep 100% of the time for the mesial root and 99% of the time for the distal root. In the maxillary molars 100% of the mesio-buccal roots have a 1 mm deep concavity while the distal has this concavity 97% of the time and the palatal has this 17% of the time. Furthermore, 75% of the time the furcation entrance is less than 1 mm, limiting the accessibility to scalers and sonic devices. For these reasons new designs and miniaturized hand and sonic instruments have been introduced in the market and have become very popular. In spite of these technological advancements, each clinician should bear in mind that the result in treating a furcation depends on the strategic value of the tooth.

Enamel Pearl Projections

Other anatomical determinants may complicate the furcation area. Enamel pearl projections have been reported in the literature as co-factors for furcation lesion formation. Masters and Hoskins (1964) found that cervical enamel projections were present at 29% of the buccal surfaces of mandibular molars, while only 17% of the observed maxillary molars had the same anatomical feature. Moskow and Canut (1990) found a lower incidence of the enamel pearl projections, with a range from 1.1% to 9.7%. The teeth with the highest frequency were the maxillary third and second molars. Two different papers (Bissada and Abdelmalek, 1973; Swan and Hurt, 1976) reported a 50% correlation between furcation involvement and enamel pearl projections. In 1987 Hou and Tsai were able to correlate furcation involvement with the presence of cervical enamel projections based on a study of 87 furcated molars that showed cervical enamel projections in 63% of the cases.

Intermediate Bifurcational Ridge

These formations can be found on the mandibular molars; they consist of cementum formation originating from the mesial surface of the distal root, extending to the mesial root. Everett et al. (1958) found that 73% of the observed extracted mandibular molars were affected by these anatomical aberrations.

Accessory Pulp Canals

Since Bender and Seltzer (1972) reported on the presence of a great number of accessory pulp canals in the furcation area of molars, many other authors have investigated the incidence of these canals and their role in the establishment of periodontal lesions. While there is enough evidence to support the fact that accessory pulp canals open in the furcation area with a great deal of frequency (with a range of 27.4% to 76%) (Lowman et al., 1973; Vertucci and Williams, 1974; Burch and Hulen, 1974; Gutman, 1978), there is still some controversy regarding their role in the pathogenesis of a periodontal lesion.

Resective Options

According to the 1992 *Glossary of Periodontal Terms* we can define the following treatment modalities:

Root amputation: The surgical removal of a root without the related crown portion (this can be done before or after the endodontic treatment).

Root resection: The removal of a root and the related crown portion from a multi-rooted tooth.

Root separation: The surgical sectioning of the root complex and the maintenance of all roots.

Hemisection: The surgical separation of a multi-rooted tooth with the extraction of one root with the overhanging crown. Usually refers to mandibular molars.

Tunnelization: Conservative treatment by creating a space between the roots that can be cleaned by the patient. (Usually refers to mandibular molars.)

The modalities are described in detail below.

Root Amputation

This treatment may be considered a conservative treatment modality; it may not include the prosthetic restoration of the involved tooth. This may be indicated whenever one of the roots is involved periodontally or endodontically and the overhanging crown is sound (Figure 7.17 a,b). In this case, after a flap is raised the root is cut right at its emergence from the root trunk. A fissure bur is used to bevel the amputation. A minimal ostectomy should be performed on the buccal aspect of the root (or palatal aspect in the case of a palatal

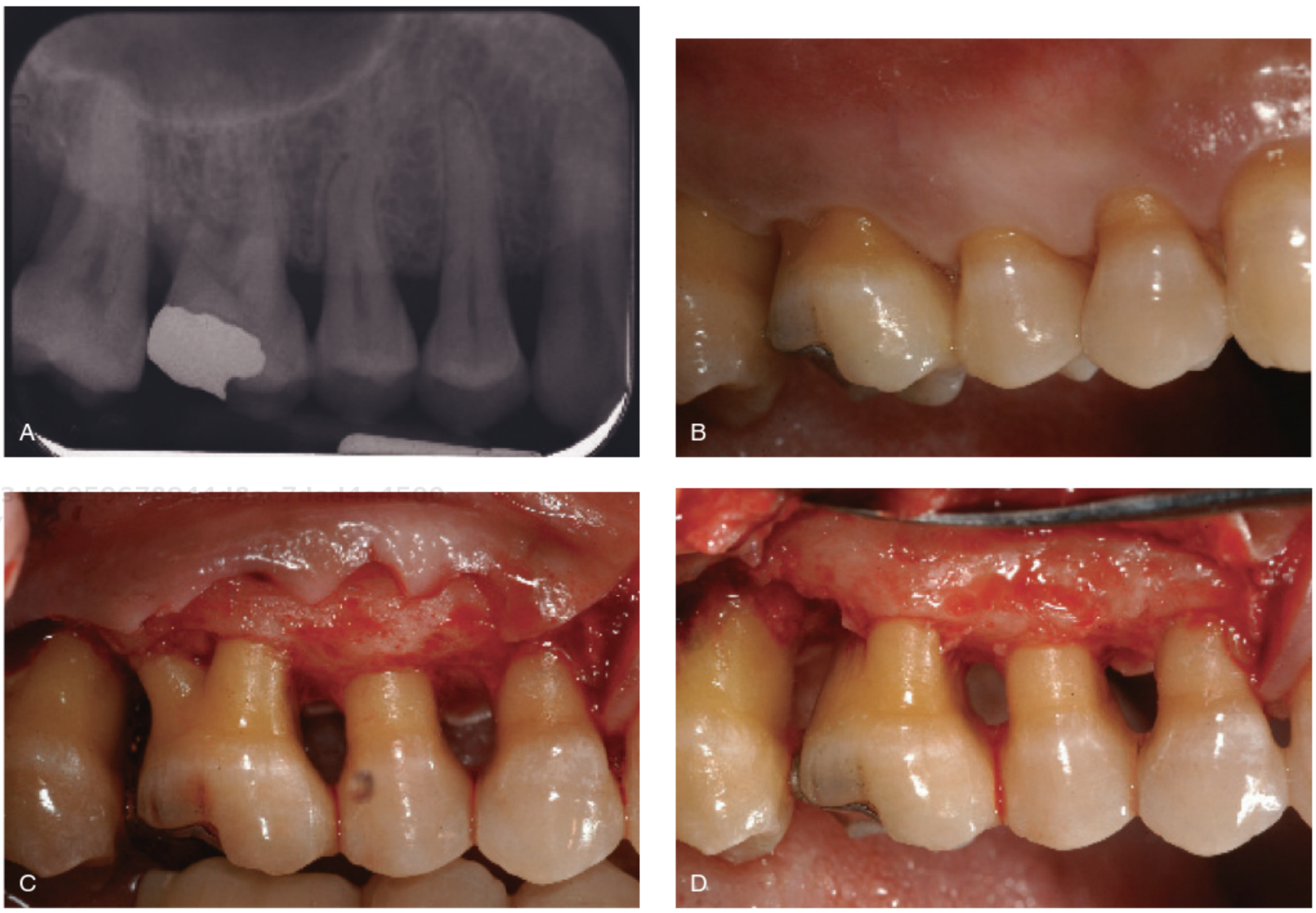

Figure 7.17. A, Radiograph of a maxillary first molar with a root proximity and a Class II defect of the buccal furcation. B, Clinical view, pre-operative. C, After mucoperiosteal flap elevation, the buccal furcation is clearly visible. D, The root amputation is performed by cutting the base of the disto-buccal root with a fissure bur to create a sluiceway to allow proper cleaning.

maxillary molar) to allow the extraction of the root without the risk of buccal bony plate fracture (Figure 7.17 c,d). Once the root is extracted the orifice on the crown should be filled and the flap sutured back. Smukler and Tagger (1976) showed in a clinical and histological study that this procedure may be carried out as an emergency procedure before endodontic treatment has been performed. The pulp of the amputated molars remains vital for up to two weeks without symptoms. However, all efforts should be made to treat the tooth endodontically before the amputation is performed.

Evidence: There is scarce evidence regarding the long-term effect of this modality of treatment.

Root Resection/Separation/Hemisection

In the case of Class II and III furcation involvement, a root resection or separation may be considered. Several factors should be evaluated before considering this option: root anatomy, root length, amount of attachment loss and attachment apparatus left on the residual roots, tooth mobility before resection, restorability of the crown, strategic importance, and alternative treatment. This treatment includes endodontic therapy, tooth reconstruction, and prosthetic coverage. All of the operators involved in the treatment must be acquainted with the objectives of the treatment so that appropriate minimally invasive root canal shaping and conservative root preparation is done.

Once the tooth has been judged appropriate for this treatment, it must undergo endodontic therapy first and then must be prepared for a complete crown coverage (Figure 7.18). After raising a flap, the furcation entrance must be clearly identified and the anatomy of the root selected for resection carefully evaluated (Figure 7.19). Using a carbide or diamond fissure bur, a trough will be outlined connecting the entrances of the two furcations. The extraction can be done once the root and the related portion of the crown are isolated (Figure 7.20). Some crestal bone may be removed to facilitate root mobilization and minimize the chance of fracture of the buccal bony plate during root extraction. At this point the residual tooth should be checked for any further furcation involvement; if this is the case a separation of the residual roots may be considered.

It is very important in this procedure to consider each separated root as an individual unit and the furcation space as an interdental area. Osseous surgery around each of the resected roots should therefore follow the same basic principles of creating a positive architecture. The amount of the attachment apparatus left on each root combined with root morphology and length determines the degree of stability of the root. It should be remembered that the majority of the attachment apparatus of a maxillary molar is in the root trunk area and that the mesio-buccal root has a greater attachment area followed by the palatal and disto-buccal roots. A maxillary molar with a short root trunk will be affected by a furcation lesion earlier, but may have a better prognosis if resective procedures are used as most of the attachment is still present. On the contrary, a long root trunk, once involved, has a lesser chance to be treated with resective means because the amount of residual attachment on the remaining root is reduced. Therefore, the root to be resected should be carefully selected both pre- and intra-operatively, particularly when mesio-buccal or palatal roots are indicated for extraction.

After root extraction and/or separation, the tooth must be reshaped and prepared to ensure physiologic soft tissue adaptation and allow patient cleansing maneuvers.

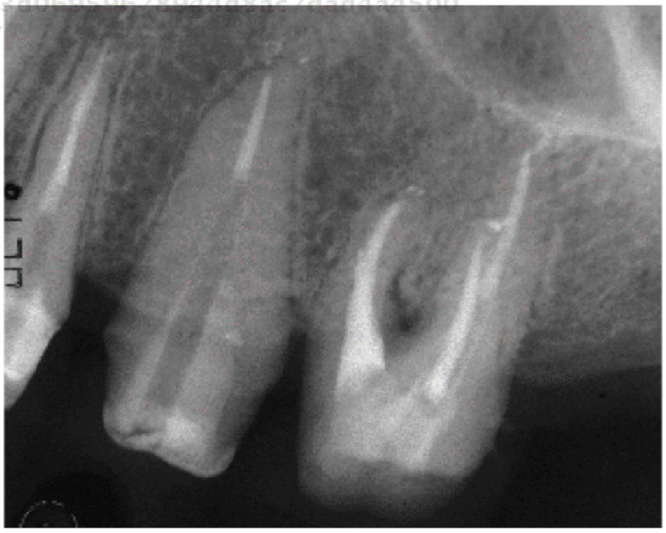

Figure 7.18. Radiographic view of a Class II furcation.

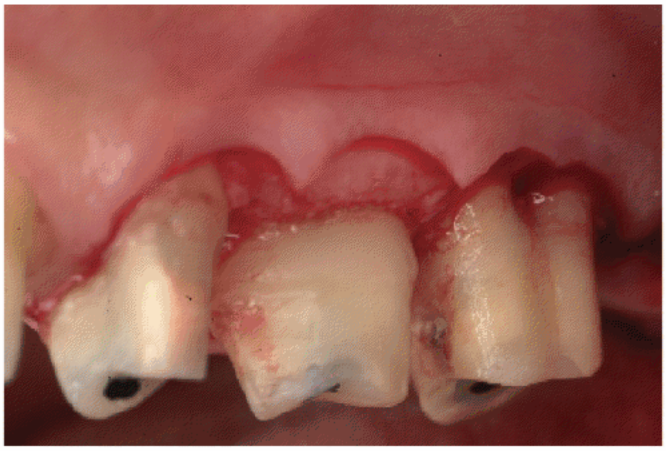

Figure 7.19. The furcation is identified and measured at flap elevation.

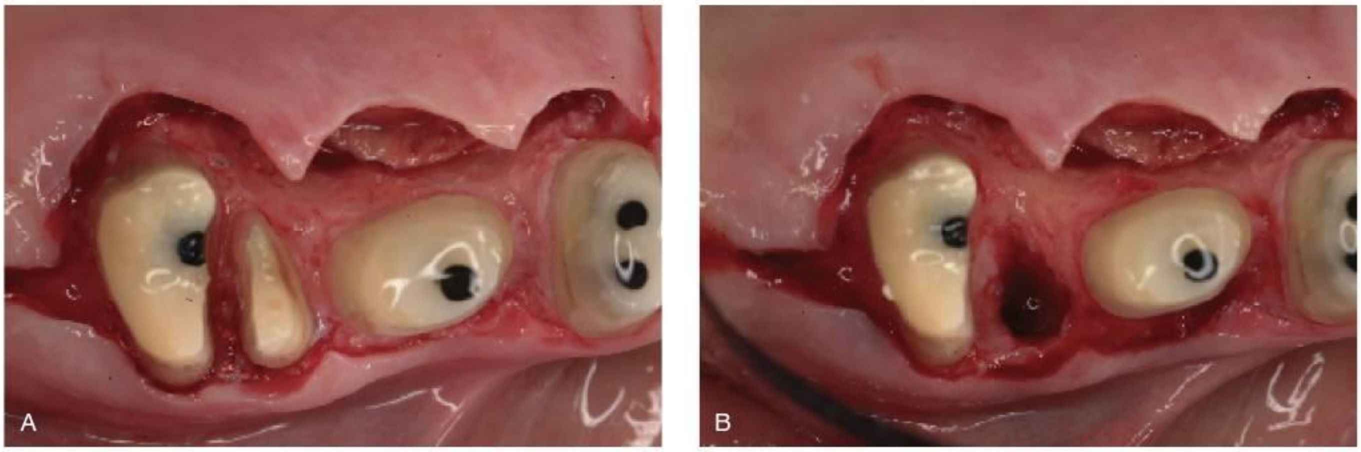

Figure 7.20. The mesio-buccal root is isolated (A) and extracted (B).

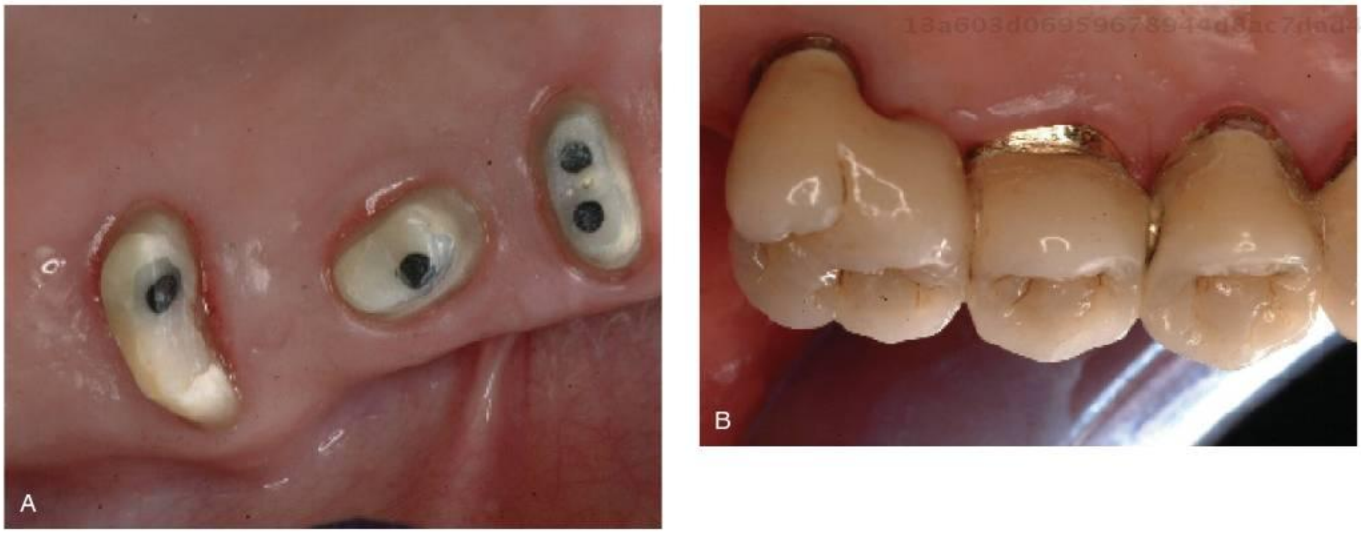

Figure 7.21. A, Two months healing demonstrates good tissue quality and adequate plaque control by the patient. B, Clinical view two years after crown delivery. C, Two-year radiographic control. Courtesy of prosthodontist Dr. Paolo Manicone, Rome, Italy.

Osteoplasty of the residual alveolus also may be indicated to allow better flap adaptation.

Temporary restorations play a significant role in this treatment technique because they ensure stability and protection of the residual tooth during the healing period. At the end of the surgery the temporary restorations should be relined and adapted, leaving the margin at least 3 mm away from the osseous crest to allow tissue maturation and establishment of physiologic supra-crestal gingival tissue (Figure 7.21). Kon and Majzoub (1992) reported that the distance between the pulp floor and the furcation entrance in maxillary resected first molars was, on average, less than 3 mm (Figure 7.22). The significance of this finding may have a major restorative impact because it may imply that all of the restorations in those areas may violate the supra-crestal gingival tissue dimension.

Root resection for mandibular molars deserves some additional considerations. Mesial root anatomy is far more complex compared to the distal root anatomy because it contains two canals and in 100% of the cases has a curvature and a deep concavity on the furcation aspect (Bower, 1979). Removal of the mesial root is therefore preferable because the distal root may be easier to restore and manage periodontally. Fracture of the resected mandibular molar is more frequent when the mesial root is retained (Langer et al., 1981). In the author's experience resection of the mandibular molar may be indicated when the adjacent teeth are involved in the prosthetic plan (Figure 7.23).

The restoration of a resected mandibular molar with an individual crown is the least advantageous because a mesial or distal cantilever is created, along with a great chance of fracture. On the contrary, once the resected molar is involved in a more extended bridgework, the mechanical loading is

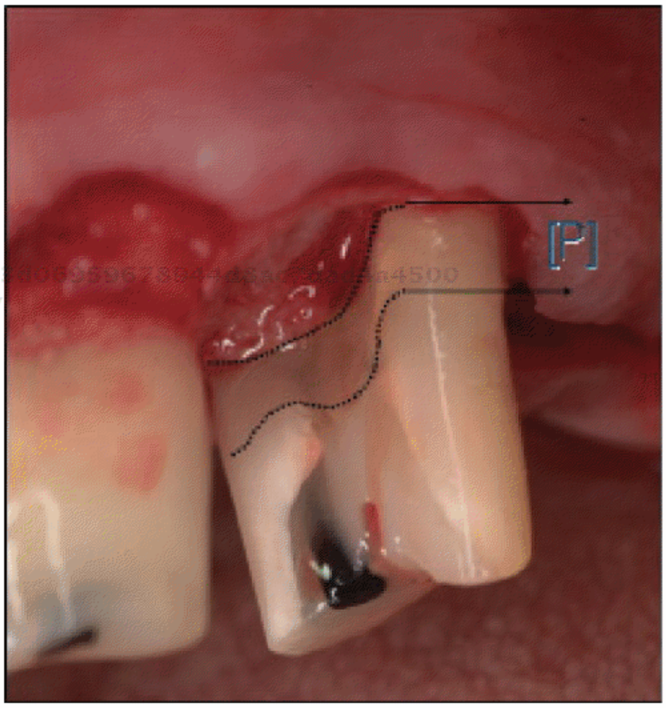

Figure 7.22. Maxillary first molar with a resected mesiobuccal root. The distance between the pulp chamber and the furcation entrance (P) is on average less than 3 mm, as in this case.

distributed along the entire bridge span, reducing the risk for fracture. Prosthetic management of resected teeth is beyond the scope of this chapter, but usually requires conservative preparations to spare as much tooth structure as possible to avoid weakening the abutments.

Mandibular furcated molars, and to a lesser extent maxillary molars, may also be treated by root separation, better known as hemisection. In this instance the roots are separated and maintained. This procedure may be indicated whenever each of the roots has an adequate periodontal apparatus and is judged to be able to be maintained from a prosthetic and endodontic standpoint. The surgical principles are the same as for root resection; however, prosthetic management may differ because a tunnelled molar crown must be fabricated to ensure good access for home care (Figure 7.24). The interproximal distance between the roots must be adequate to allow space for the crown margin (that should only be made of metal) and for interproximal space. Therefore, molars with a narrow inter-radicular space or with roots that connect or converge toward the apex may not be candidates for this treatment modality. The use of an orthodontic device to increase the inter-radicular space has also been advocated, even though it may increase the complexity and length of the therapy.

Evidence: Gathering a general consensus on the effectiveness of root resection therapy on a long-term basis may not be so easy. Conflicting data can be found in the scientific literature regarding this subject. Poor treatment outcomes on a long-term basis have been reported by Langer et al. (1981), who in a 10-year study found that 38 of 100 resected molars had to be extracted. The main reasons for failure were root fracture (18%), periodontal breakdown (10%), and endodontic lesion (7%). Only three teeth failed because of cemental leakage and recurrent decay. Buhler (1988) reported a 32% failure rate at 10 years on 34 resected molars. Again, the main causes of failure were endodontic pathology and root fracture, while only one tooth was extracted due to periodontal breakdown. The same failure rate was found by Blomlof et al. (1997) in a follow-up three to 10 years later. The results of this study should be interpreted with caution because the authors compared the survival of 146 root-resected molars with 100 endodontically treated single-rooted teeth. Interestingly, at five years the survival rate between the two groups did not differ significantly (82% vs. 83%), while at 10 years the survival rate for multi-rooted teeth dropped to 68% compared to 77% of single-rooted teeth. These differences, however, did not provide statistical significance. In this study the primary reason for failure was recurrence of periodontitis, and smoking was identified as a strong risk factor in this group of patients.

On the other hand, several studies report favorable results with the use of root resection. Taken together, the failure rate

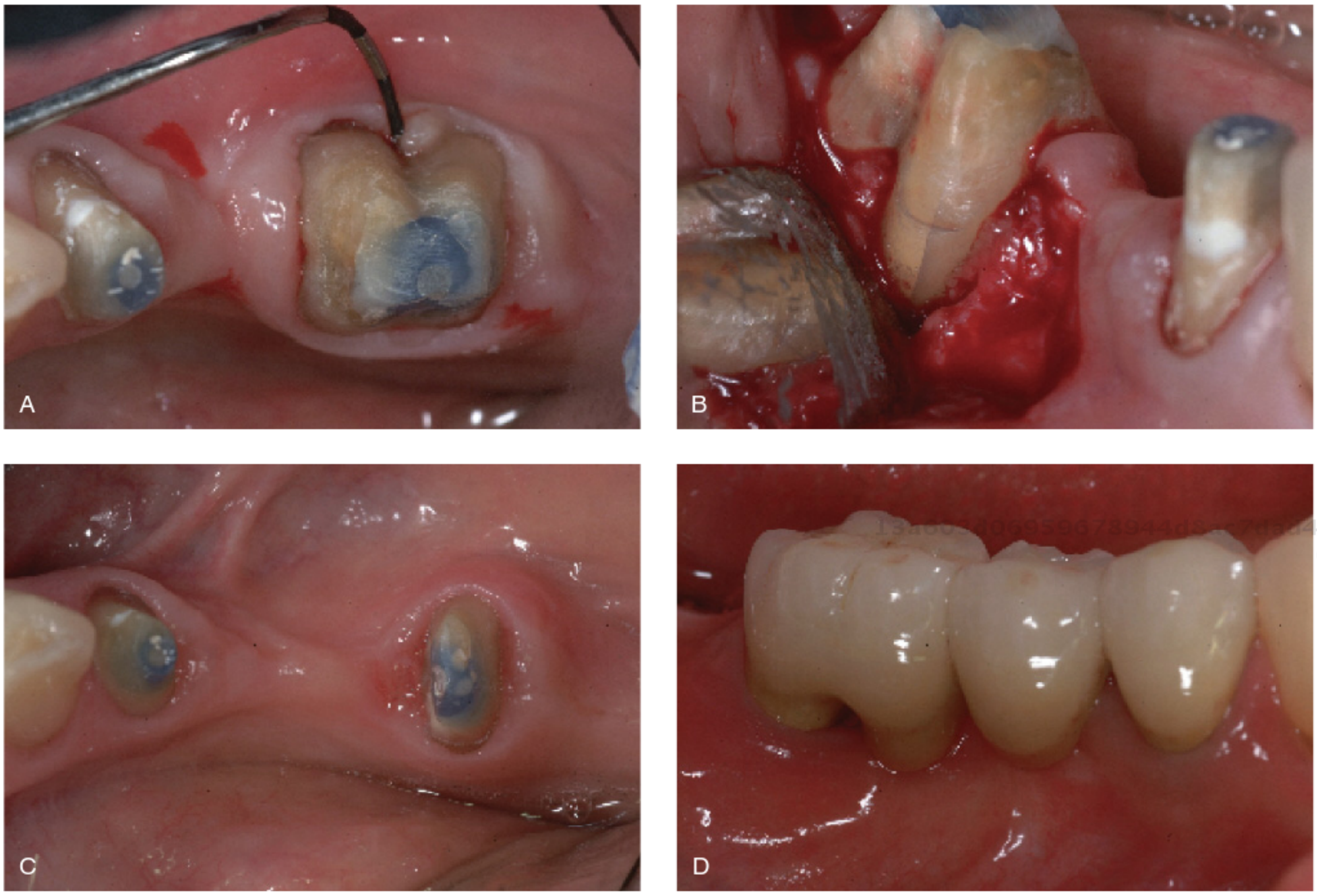

Figure 7.23. A, Lower right first molar with a Class I furcation. B, A vertical fracture of the mesial root is found and the tooth is resected with the extraction of the mesial root. C, Three months after the extraction the distal root is checked for stability and a final fixed partial denture is delivered. D, The pontic design should be adequate to allow good home care. Courtesy of prosthodontist Dr. Paolo Manicone, Rome, Italy.

described in those studies ranged from zero to 8%, at two to 23 years of follow-up. Hamp et al. (1975) reported on the effect of various treatment modalities in the case of furcation involvement of 310 molars. Eighty-seven of these teeth received root resection. After five years no teeth were lost and periodontal conditions were stable; only two teeth had a probing depth greater than 6mm. This would indicate that a change in the supra- and sub-gingival environment, allowing good self-performed home care, may be critical for periodontal stability. The same periodontal success has been reported by Erpenstein (1983), treating 34 molars with root resection. During the average follow-up time of 2.9 years (range one to seven years) only four teeth were lost, three of which had endodontic failure.

The main study dealing with root resection therapy is the one from Carnevale and co-workers (1998), who treated 194 patients for a total of 488 resected molars. All of the teeth were prosthetically restored. The follow-up time ranged from three to 11 years. At the end of the study all of the patients were included in a strict regimen of supportive therapy. The success rate was 94% (28 teeth failed) and the reasons for failure included endodontic recurrence (four teeth), caries (nine teeth), abutment fracture (three teeth), and root fracture (nine teeth). Three teeth with a probing depth of greater than 5mm were also included as failures. The conclusion of this study was that resective therapy may be considered to be a viable option in the treatment of advanced periodontal disease on a long-term basis.

Comments: Root resection therapy is a highly demanding procedure that can still be considered an option in the armamentarium of a periodontist. The introduction of implant therapy has greatly affected the application of this technique in the daily practice. Nevertheless, any time the decision whether to treat and maintain a multi-rooted tooth or extract and replace it with an implant has to be made, there are several considerations. These considerations must be made

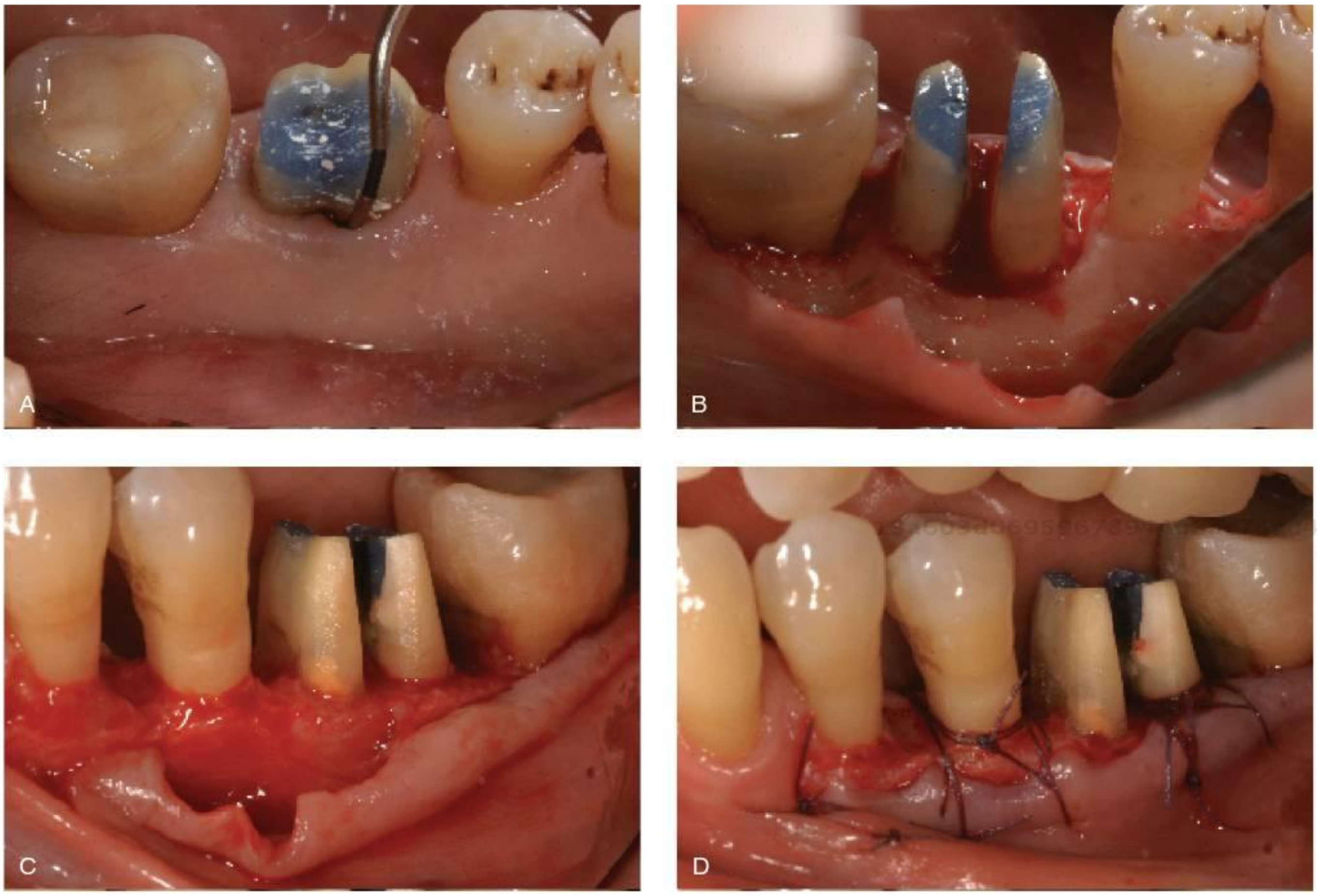

Figure 7.24. A, A Class II lingual furcation is detected at the lower left first molar. B, A root resection is performed and an osteoplasty is also carried out to reduce the infrabony defect around the roots on the lingual side. C, A buccally minimal ostectomy is necessary. D, The buccal flap is apically repositioned using continuous sling vertical mattress sutures. E, Three weeks' healing after surgery. Courtesy of prosthodontist Dr. Antonello Pavone, Rome, Italy.

by every single member of the restorative team because a team effort is required to achieve a predictable result:

- The endodontist should perform the least invasive therapy possible, sparing as much root structure as possible.
- A fiber post or post and core reconstruction with a temporary crown should be done before resective surgery is initiated.
- A positive architecture must be achieved during surgery and the tooth profile must be reshaped to ensure good access for maintenance and easy prosthetic finalization.
- The precision of the final crown is a critical step and the lab technician should be instructed to create space for cleaning.
- A strict periodontal support program is critical to achieve long-term success, as has been widely demonstrated by several authors (Axelsson et al., 1981).

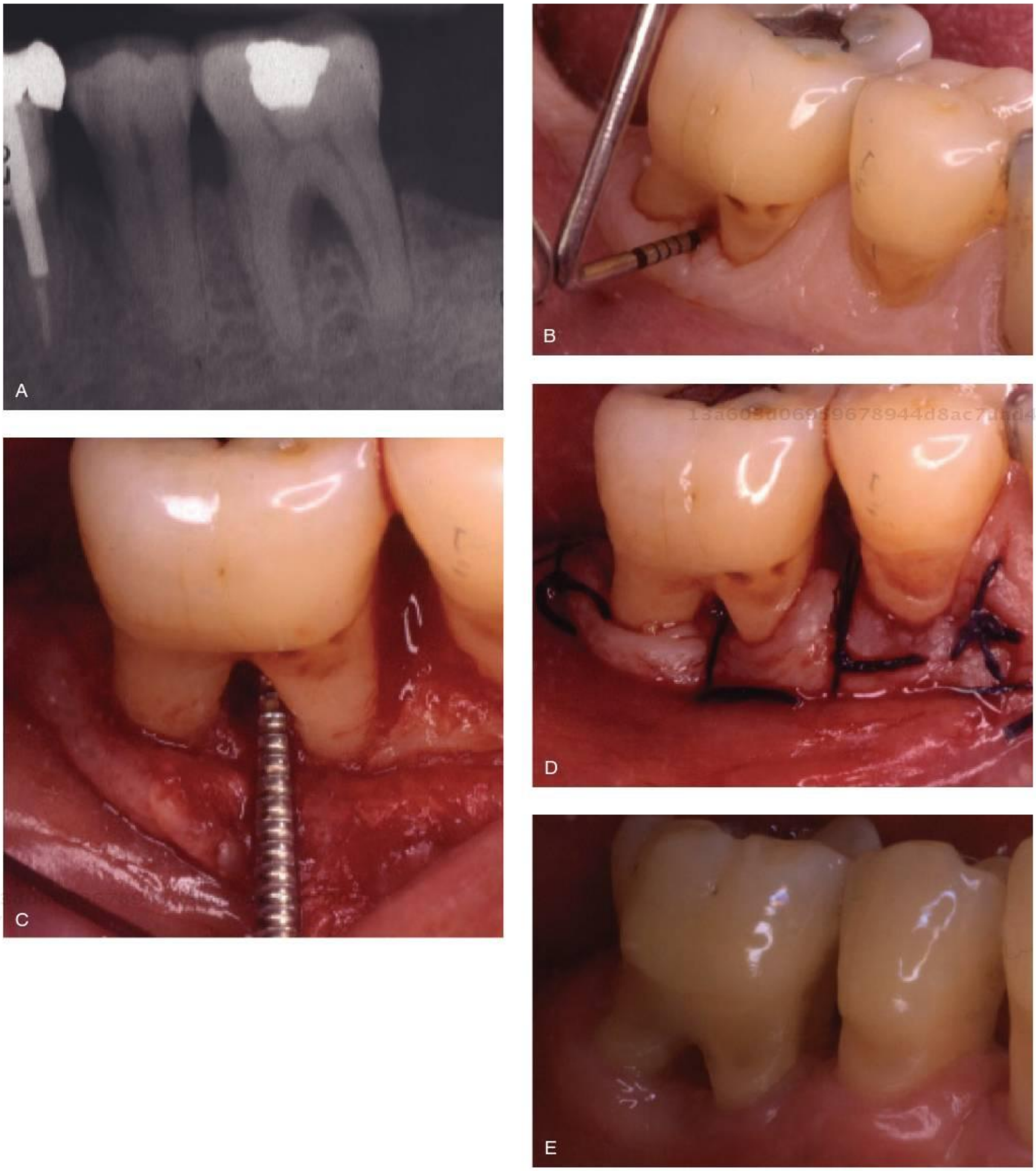

Figure 7.25. A, A Class III furcation defect is documented radiographically, and B, clinically. C, Tunnelization is performed, and using a Sugerman bone file, the interradicular space is widened and the bone crest flattened. D, Silk sutures provide apical displacement of the tissue. E, Six months' healing shows an adequate opening of the furcation area for cleaning. F, Radiograph at one year, suggesting corticalization of the inter-radicular bone crest at the first molar with no sign of further loss of support.

Figure 7.25. continued

Although all of these steps may seem overwhelming, the extraction of a periodontally compromised maxillary molar and its replacement with an implant may not be as hard as it seems. One should note that most of the time the sinus in that area is highly pneumatized and drops into the inter-radicular space. Once the tooth is extracted, an alveolar bone remodelling takes place, further reducing the amount of remaining crestal bone. Furthermore, posterior maxillary sextants are physiologically associated with poor bone quality, which is directly correlated with a higher implant failure rate (Jaffin and Berman, 1991). Therefore, the alternative to root resection therapy may be tooth extraction followed by sinus elevation surgery and implant placement. Although this procedure is now considered to be routine, with good results (Del Fabbro et al., 2004), the data are rarely higher than those reported by Carnevale et al. (1998). A careful evaluation of each individual case, considering patient risk profile, local determinants, and possible alternatives, is always recommended.

Tunnelization

This conservative technique has been employed in the treatment of advanced furcation lesions that mainly affect mandibular molars. The primary indication for this approach is the case of an existing Class III furcation with no or a minimal vertical component (Figure 7.25). The anatomy of the affected molar is critical to determining the possibility of performing this procedure. Usually a short or medium root trunk with divergent and long roots may be considered as an ideal candidate for this treatment. The technique includes a certain degree of osteoplasty/ostectomy to widen the furcation entrance and achieve a flat bone crest anatomy.

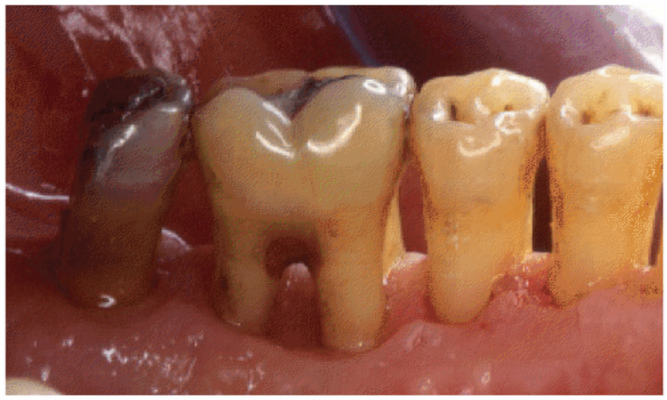

Figure 7.26. Caries at the furcation of a tunnelized lower left first molar. The unrestored mesial root of a resected second molar is also present. The lack of an adequate prosthetic plan may well be considered a major drawback in this case.

Some odontoplasty has also been proposed to obtain better access to the furcation area. This should be done with great care because it may cause tooth hypersensitivity. Therefore, it is suggested that odontoplasty of the furcation entrance only be performed in the case of an endodontic-treated tooth or when the distance between the dome of the furcation and the floor of the pulp chamber is adequate. Once the osseous resection is accomplished the flap is apically positioned and a mattress suture is passed through the furcation to hold down the flap. As soon as the sutures are removed the patient must be instructed to use an interproximal brush or a superfloss to ensure good cleaning of the area.

Evidence: No large studies reporting on this technique have been published in the literature. Relative periodontal stability has been reported using this technique (Little et al., 1995; Muller et al., 1995). According to several authors, the major complication is related to the development of caries in the furcation area (Figure 7.26), with an incidence that ranged from 10% to 57% up to five years. (Hamp et al., 1975; Hellden et al., 1989; Ravald and Hamp, 1981). Other authors were unable to report the same cario-susceptibility and described more favorable long-term results. A recent publication by Feres and co-workers (2006) reported on 30 tunnelized teeth in 18 subjects who were followed for a mean period of 3.6 years. Four teeth (13.4%) showed active caries, while there was no difference in the carious lesion between the inner and outer furcation area. Probing depth was, however, higher inside of the furcation compared to the radicular and interproximal sites.

AUTHOR'S VIEWS/COMMENTS

This treatment should be reserved for those cases in which a compromised treatment option is selected for strategic or financial reasons. In addition, careful analysis of the tooth anatomy and morphology (root length, interradicular space, root curvatures, etc.) must be reviewed before performing the procedure.

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