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Osseous resective surgery

GIANFRANCO CARNEVALE & WAYNE B. KALDAHL

History

The removal of superficial radicular and interproximal alveolar crestal bone has been utilized for over a century in conjunction with the treatment of periodontal disease. Actually, Pierre Fauchard in 1776 made reference: "if however the bone is carious then it must be uncovered to its whole extent and the cure carried out" (24). The earlier rationale for osseous surgery was that the bone surface was considered infected or necrotic and had to be removed. Many therapists in the late 1800s and early 1900s, including S. Robicsek, G.V. Black, A.D. Black, A. Crane, H. Kaplan, A. Ward and W. Ziesel, advocated gingivectomy surgery with denudation of the radicular and interproximal crestal bone followed by some osseous removal. Most of the early pioneers in flap surgery, such as R. Neumann, A. Cieszynski and A. Zentler, also removed bone because its surface was considered necrotic (10). L. Widman, however reshaped the alveolus to facilitate flap replacement, and Neumann also tried to recontour bone to mimic more normal anatomy (33). The classic work by R. Kronfeld published in 1935 proved that the bone was not infected or necrotic and therefore did not need to be removed (49). F.A. Carranza, Sr. also published an early article on the recontouring of bone to facilitate the reduction of pockets by allowing the gingival tissues to follow a more physiological contour (10). A classic article by S. Schluger in 1949 outlined the principles of osseous surgery for the purpose of recontouring the bone so that the elimination of the periodontal pocket was predictable and less likely to return over time (77). Schluger and his early colleagues, J. Prichard, N. Friedman and C. Ochsenbein, popularized the use of osseous surgery in the treatment of periodontitis.

Definitions

The following pertinent definitions are from the third edition of the American Academy of Periodontology's *Glossary of periodontal terms* (32):

- Osseous surgery: periodontal surgery involving modification of the bony support of the teeth.
- Osteoplasty: reshaping of the alveolar process to achieve a more physiological form without removal of supporting bone.
- Ostectomy: the excision of bone or portion of a bone. In periodontics, ostectomy is done to correct or reduce deformities caused by periodontitis in the marginal and intra-alveolar bone and includes the removal of supporting bone.

Indications and endpoints of osseous resective surgery

Osteoplasty is used to treat buccal and lingual bony ledges or tori, shallow lingual or buccal intrabony defects, thick interproximal areas and incipient furcation involvements that do not necessitate removing supporting bone (28, 63, 64, 70). Ostectomy is utilized to treat shallow (1–2 mm deep) to medium (3–4 mm deep) intrabony and hemiseptal osseous defects and correct reversals in the osseous topography (34, 65, 66, 77). The endpoint of osteoplasty, used in conjunction with a modified Widman flap or an apically positioned flap, is the enhancement of tissue placement and adaptation at the time of suturing (73). The endpoint of ostectomy, used in conjunction with an apically positioned flap or a thinned palatal flap, is the elimination of an intrabony pocket (15). Osseous resective surgery is the combined use of both osteoplasty and ostectomy to re-establish the marginal bone morphology around the teeth to resemble "normal bone with a positive architecture", albeit at a more apical position. By definition, "normal bone with a positive architecture" means that the surface of interdental bone is coronal to that of the facial and lingual radicular bone (65, 71). The endpoints of osseous resective surgery are minimal probing depths and a gingival tissue morphology that enhances good self-performed oral hygiene and periodontal health.

Since most clinical reports and experimental trials on regenerative procedures involve intrabony or hemiseptal defects of ≥4 mm depths (23, 84, 85, 87), we believe that, as a general rule, only ≤3 mm intrabony or hemiseptal defects are suitable for osseous resective surgery procedures. This creates a clear-cut difference in the indications for the two surgical procedures. It is recognized that many variables with osseous resective surgery alter clinical judgment and will be assessed later. Besides the treatment of intrabony and hemiseptal defects, osseous resective surgery is also utilized in preprosthetic, restorative and cosmetic surgery to increase the clinical crown length and/or to re-establish an "adequate" zone of natural root surface for the gingival attachment.

Surgical technique

Resorption of the osseous margin with an apical shift of the connective tissue and junctional epithelial attachment occurs with periodontitis (67). The magnitude of the destructive lesion from the plaque front colonizing the tooth is relatively small (~2.5 mm) (50, 82, 89) and involves both hard and soft tissues in an apical and lateral direction, forming a "void" or "defect" in the alveolar bone adjacent to the root. The less affected surrounding bone is in a more coronal position and constitutes the bony walls of the defect (that is, intrabony or hemiseptal). This surrounding bone, which experiences less resorption, provides the scaffolding support that holds the gingival complex in a coronal position, while the connective tissue and junctional epithelial attachment at the base of the defect are located in a more apical position. This results in an increased distance from the gingival margin to the apical portion of the junctional epithelium (that is, intrabony pocket formation with increased probing depth). On the contrary, when the alveolar housing of a tooth is thin or narrow, the resorptive lesion generally encompasses the complete osseous margin, leaving the gingival complex without support (82). In such cases, depending on the soft tissue thickness, a suprabony pocket forms with increased probing depth or, more often, the gingival margin recedes. Periodontitis forms localized lesions at specific sites and an uneven osseous topography therefore develops, not only around one involved tooth but also around and between several teeth.

Fig. 1. Flap thickness. The palatal flap was incised with even thickness both in the radicular and interdental areas.

The connective tissue and junctional epithelial attachment to the tooth, averaging 2 mm in width, lie just coronal and adjacent to the osseous margin both apically in the base of the intrabony and hemiseptal defects and coronally over the bone making up the defect's walls (13, 31). A pocket is likely to persist as long as the osseous walls of the intrabony defect are present to hold the gingiva in the more coronal position.

The ideal method of eliminating the intrabony or hemiseptal defect and its associated pocket is the regeneration of lost bone, periodontal ligament and cementum that results in a new coronal position of the connective tissue and junctional epithelial attachments. The other approach of eliminating the intrabony defect and its periodontal pocket is to remove the walls of bone that make up the defect and to place the gingival complex in a more apical position. To achieve the desired physiologically scalloped bone anatomy, reversals in the osseous topography (i.e., surface of facial or lingual radicular bone being in a more coronal position than the interproximal bone) are also corrected. The removal of both supporting bone (ostectomy) and nonsupporting bone (osteoplasty) from the involved tooth or adjacent teeth with utilization of the apically positioned flap is osseous resective surgery.

Soft tissue management

Because the immediate endpoints of osseous resective surgery are not only the elimination of the intrabony or hemiseptal osseous defects but also minimal (≤3 mm) probing depths and a gingival anatomy that facilitates periodontal maintenance, the soft tissue flap must be properly managed. The flap is thin and of even thickness with the final position of its margins at the level of the osseous crest (that is, apically positioned flap margin); the interproximal areas are generally not covered by

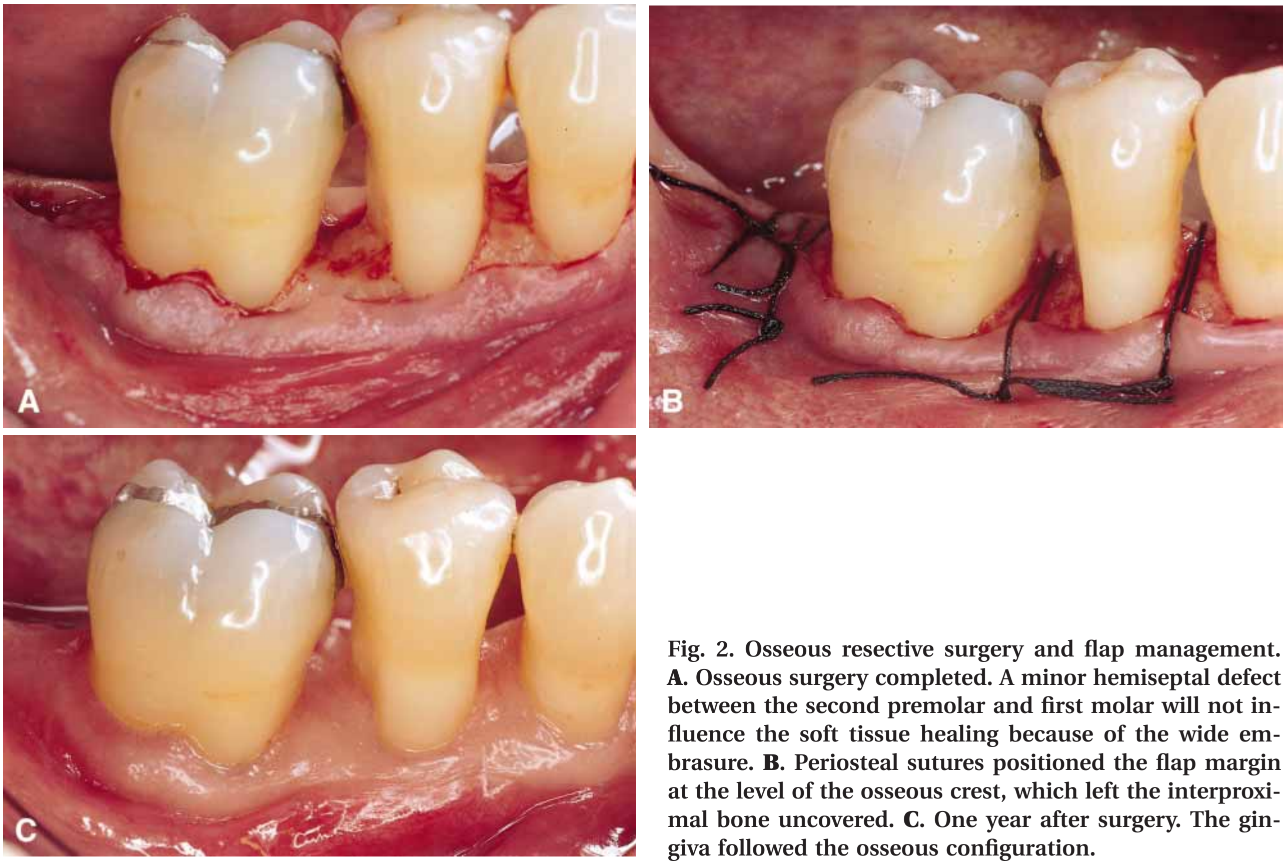


Fig. 2. Osseous resective surgery and flap management. A. Osseous surgery completed. A minor hemiseptal defect between the second premolar and first molar will not influence the soft tissue healing because of the wide embrasure. B. Periosteal sutures positioned the flap margin at the level of the osseous crest, which left the interproximal bone uncovered. C. One year after surgery. The gingiva followed the osseous configuration.

gingival tissues and therefore heal by secondary intention (Fig. 1, 2). If the projected final position of the alveolar crest, in the mandibular buccal and lingual and maxillary buccal areas, is apical to the mucogingival junction, the gingival flap is dissected in a way that allows its movement in an apical direction (29, 60). A precise anchorage of the flap in the desired position can be enhanced by initially performing a split-thickness or a thinned full-thickness or split-thickness flap that is then secured with periosteal sutures. Mesial and/or distal vertical releasing incisions extending into the alveolar mucosa are also utilized if the flap cannot be sufficiently mobilized (2) (Fig. 3). In the palatal area, the flap cannot actually be apically positioned. The palatal flap is thinned and scalloped to place the gingival margin at the crest of bone (18). Vertical incisions also may be necessary in the palatal area to gain good access to the underlying structures (Fig. 3).

The primary scalloped incision of the apically positioned flap can be intrasulcular or at various distances from the gingival margin. The probing depth and the apicocoronal dimension of the keratinized tissue dictate the design and the position of this incision. If there is an “adequate” dimension of gingiva, the distance of the primary incision from the gingival margin is proportional to the differences in probing depths of the adjacent teeth. The apical positioning of the flap allows the gingival margin to coincide finally with the osseous crest (Fig. 4). If there

Fig. 3. Flap placement. Apically positioned buccal and thinned palatal flaps were sutured with their margins at the osseous crests. Vertical releasing incisions improved access and mobilized the buccal flap for apical positioning.

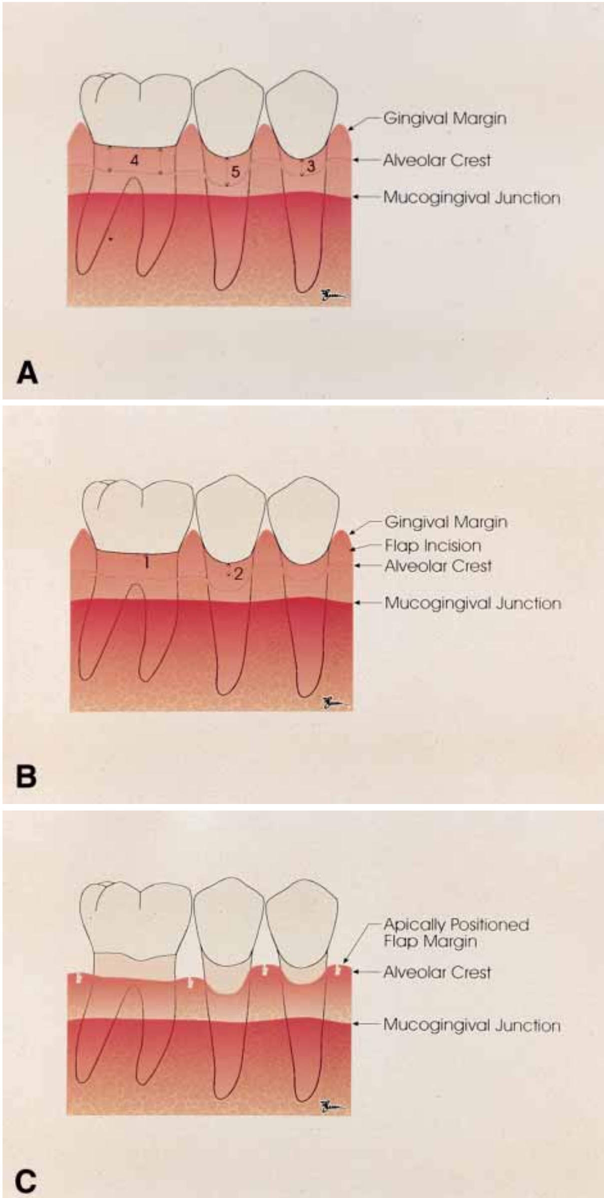


Fig. 4. Incision design with "adequate" dimension of gingiva. A. If the alveolar crest is 3 mm apical from the gingival margin on the first premolar, 5 mm apical on the second premolar and 4 mm apical on the first molar, (B) the primary scalloped incision of the flap is made at the level of the gingival margin on the first premolar, 2 mm apical from the gingival margin on the second premolar and 1 mm apical on the first molar. C. At the time of suturing, the flap coincides with the alveolar crest because of its apical positioning (3 mm).

is "inadequate" keratinized tissue, the primary incision should be intrasulcular and the flap apically positioned at the osseous crest. Vertical releasing incisions can facilitate the final tissue position. In the palate, the position of the primary scalloped incision and thinning of the flap are dictated by the probing depth of the involved teeth and by the anatomy of the palatal vault. In the case of a deep palatal vault, the distance of the primary incision from the gingival margin is approximately coincidental with the probing depths; in the case of a shallow palatal vault the primary incision is closer to the gingival margin (Fig. 5).

Specific considerations in soft tissue management are made in cases when osseous resective surgery is performed in areas of aesthetic concern such as the maxillary anterior sextant. When a natural dentition is treated or prosthetic form and contour modifications cannot compensate for unaesthetic postsurgical changes, the primary concern is to limit the soft tissue recession both in the buccal radicular and in the interproximal aspects. The papilla preservation technique in association with a thinned palatal flap can be used in such cases (81) (Fig. 6). A palatal ap-

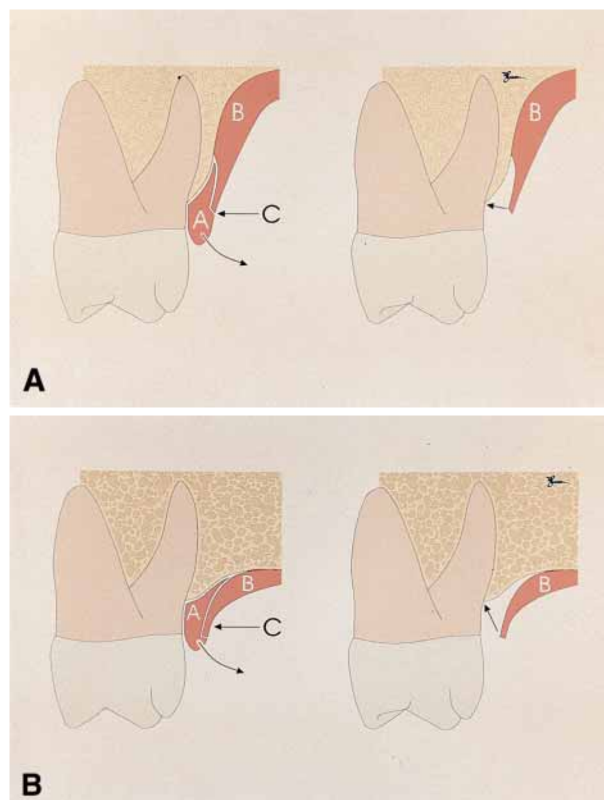


Fig. 5. Thinned palatal flap. A. With a deep palatal vault, the primary incision (C) of the thinned palatal flap is approximately coincident with the probing depth. Once the secondary flap (A) has been removed, the primary flap (B) will move horizontally to cover the alveolar crest. B. With a shallow palatal vault the primary incision (C) of the thinned palatal flap is close to the gingival margin. Once the secondary flap (A) has been removed, the primary flap (B) will move vertically in an apical direction to cover the alveolar crest.

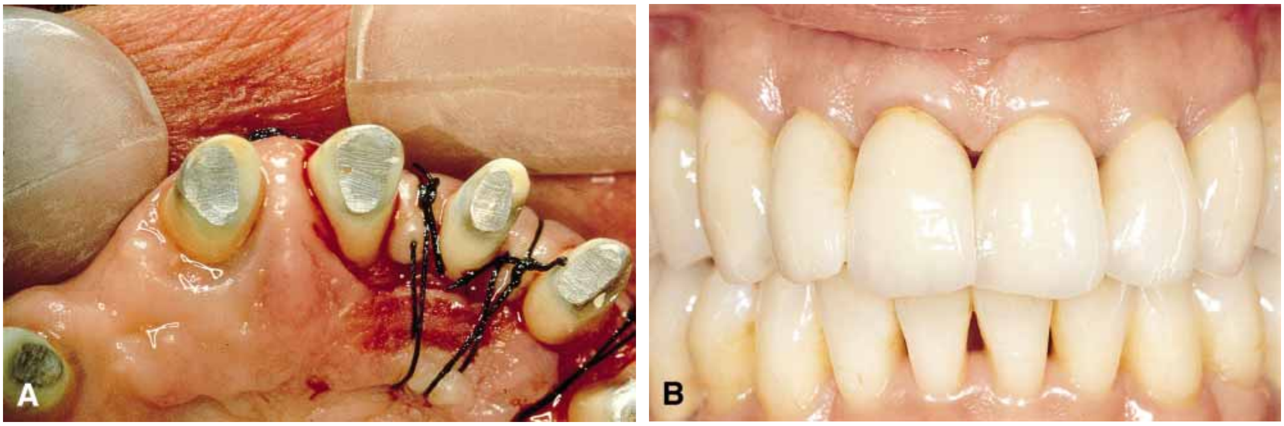


Fig. 6. Papilla preservation technique. A. The papillae between the left central and lateral incisors and cuspid were preserved as part of the buccal flap reflection and are sutured back after osseous resective surgery. Palatal flap has been thinned. B. Five years after surgery the preserved papillae provide acceptable aesthetics with the final metal-ceramic restoration.

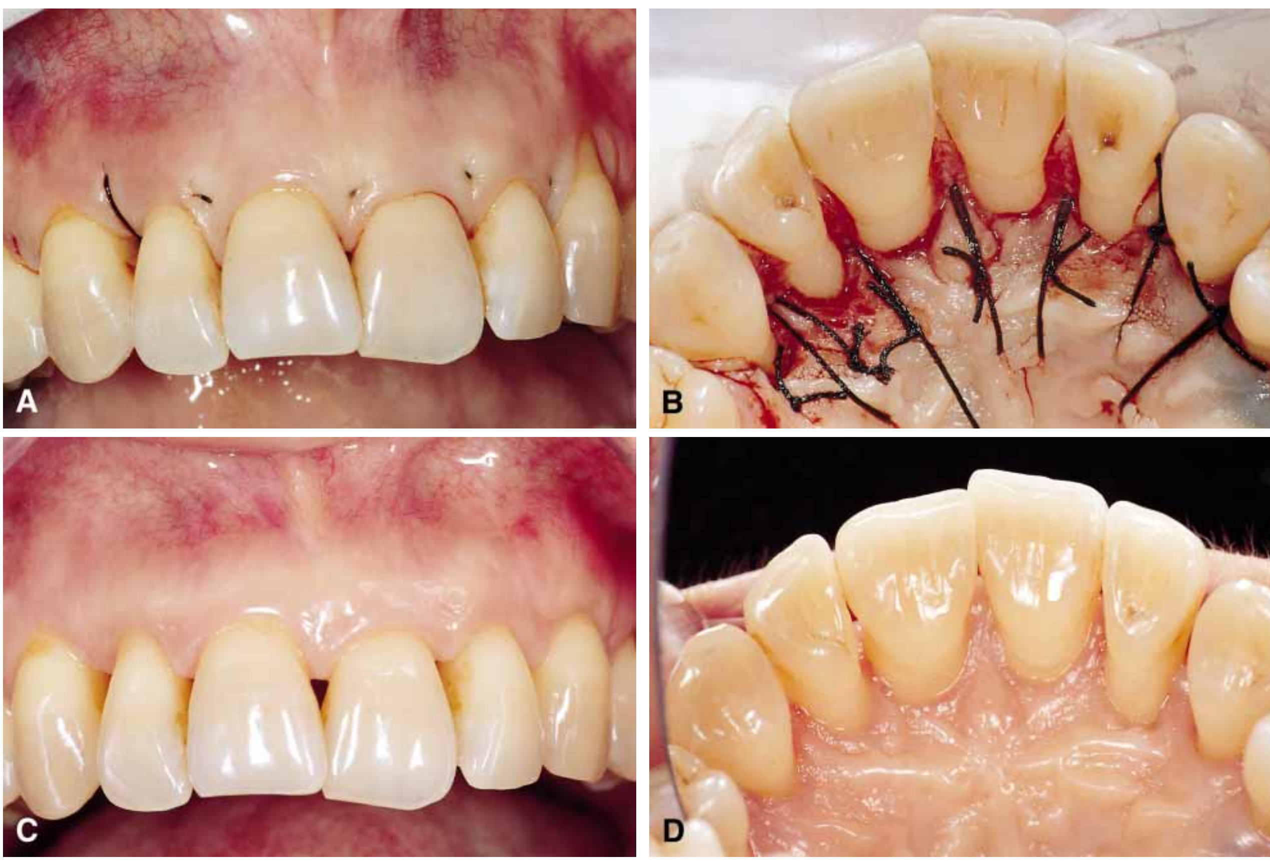


Fig. 7. Osseous resective surgery with a palatal approach. A, B. After osseous resective surgery was performed from the palatal aspect, the thinned palatal flap was anchored with interrupted sutures to the intact buccal gingiva. C, D. Three months after surgery, the anterior aesthetics were preserved. The recession on the upper left cuspid was corrected with a coronally positioned flap covering a connective tissue graft.

proach without the use of a buccal flap can be utilized if the osseous defects are confined only to the palatal aspects (Fig. 7). The general principles of the soft tissue management in osseous resective surgery are, conversely, utilized in the maxillary anterior area to perform crown lengthening procedures to overcome aesthetic problems associated with a “gummy smile” (Fig. 8).

Fig. 8. Surgical correction of a gummy smile. A. Maxillary anteriors with short clinical crowns. B. Apically positioned flap sutured after osseous resective surgery was performed to lengthen the clinical crowns. C. One year after surgery. D, E. Patient's smile before and 1 year after surgery.

Hard tissue management

Three broadly defined anatomical alveolar abnormalities are treated with osseous resective surgery.

Intrabony and hemiseptal osseous lesions. Osseous resective surgery reshapes the abnormal bone topography, caused by periodontitis, to a form that resembles normal physiological alveolar anatomy. All the walls of bone of an intrabony or hemiseptal defect are removed so that the prior apically located base of the defect is now even with the adjacent bone (34). An awareness of the local anatomical situation in the area being surgically treated along with good clinical sense are important in determining not only the amount but also the location of osseous removal. The buccal-lingual angulation of the teeth in the alveolus and the location of the osseous defect in the interproximal region may dictate bone removal in a way that creates an asymmetrical slope of the interdental osseous crest. For instance, the mandibular molars usually tilt lingually and therefore the lingual furcation as well as the lingual cementoenamel junction are in a more apical location than the corresponding buccal area. If a two-wall interproximal crater, which tends to be towards

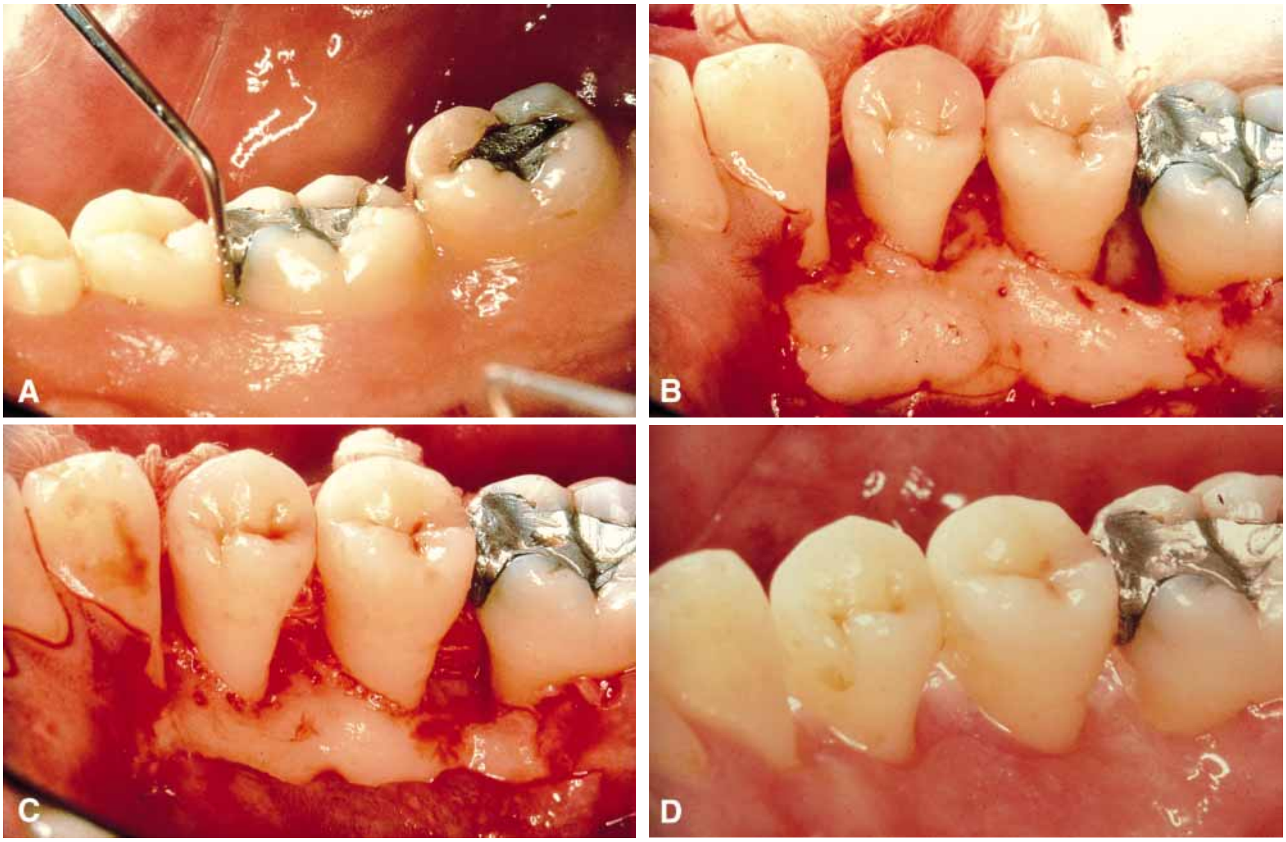
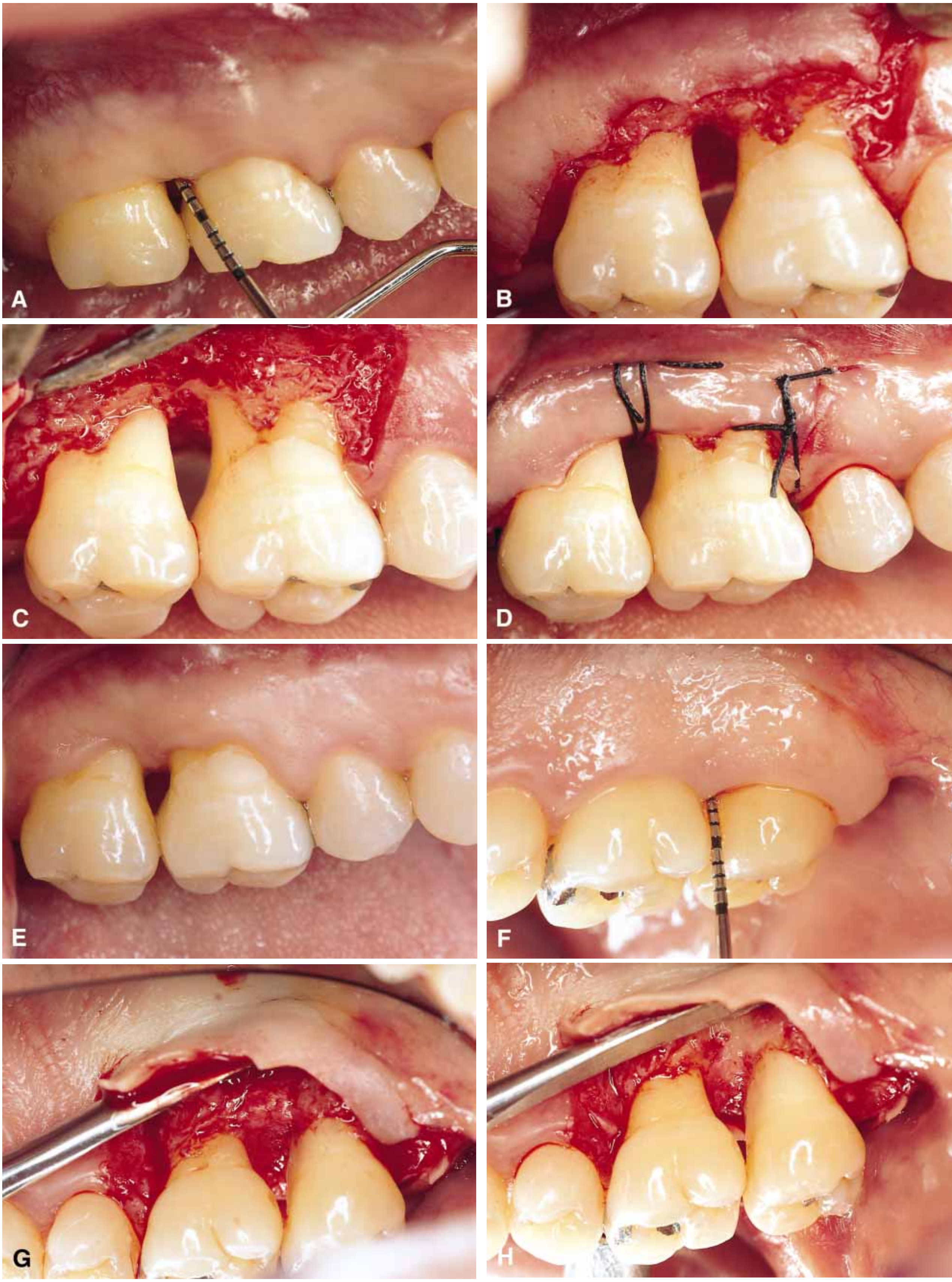


Fig. 9. Interproximal osseous ramping. A. Presurgical view with 6 mm probing depth on mesial of first molar. B. Deep two-wall intrabony defect between the second premolar and first molar, hemiseptal defect between the two premolars and lingual exostosis. C. Osseous resective surgery eliminated the interproximal osseous defects by ramping to the lingual, corrected the reversed osseous topography and removed the osseous ledges. D. Normal scalloped gingival morphology and good health 6 months after osseous resective surgery.

the lingual, is being eliminated, more of the interproximal crater's lingual wall of bone is removed, rather than the facial, thereby creating an apical slope of the interproximal bone crest from a buccal to lingual direction (that is, ramping) (83) (Fig. 9). A similar situation may exist with the maxillary molars, and the ramping can be either towards the palate or buccal area depending on the location of the interproximal defects.

Reversed osseous topography. Reversals of the bony architecture (that is, facial or lingual radicular osseous surface in a more coronal position than the interproximal surface) are often present as a result of periodontitis or ostectomy performed to eliminate the osseous walls of an intrabony or hemiseptal interproximal defect. This anatomical situation is the reverse of normal and its correction is performed by removing the facial and/or lingual bone over the roots to a level where its radicular osseous margin is apical to the interproximal bone level. This recreates the physiological scalloped appearance of the alveolus from a facial and/or lingual view (Fig. 10).

Upon examining 118 human skulls with intact and presumably periodontally healthy dentitions, O'Connor & Biggs (62) made observations about the alveolar bone anatomy that should be considered when trying to mimic the morphology of normal structures. The interproximal osseous surfaces in a buccal to lingual perspective are predominantly flat in the molar regions. They are progressively more convex in the more anterior regions of the mouth. The best guide clinically for the proper interproximal bony architecture seems to be the interproximal configuration of the cementoenamel junction of the adjacent teeth. This study casts doubt on the advisability of making all the interproximal areas convex with osseous resective surgery (62). Likewise, if healthy posterior areas have flat interproximal contours buccal-lingually, then possibly flat anterior interproximal areas can be maintained.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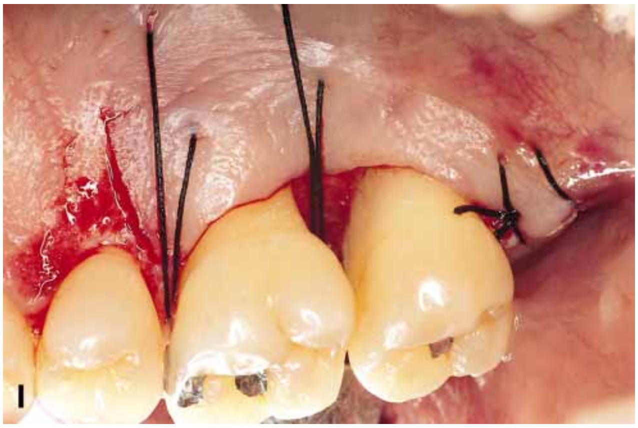


Fig. 10. Correction of isolated deep defect. A. Presurgical facial view of deep interproximal probing depth (7 mm) between molars after nonsurgical therapy. B. Buccal partial thickness flap with vertical releasing incision and distal wedge revealed a deep interproximal osseous crater. C. Osseous resective surgery removed the buccal bony wall of the intrabony defect and corrected the reversed architecture by removing buccal radicular bone, more so over the mesiobuccal root of the second molar and distobuccal root of the first molar. D. Buccal flap sutured at the level of alveolar crest. Vertical incision extending into alveolar mucosa and periosteal sutures allowed the short flap to be positioned and anchored apically. E. Six months after osseous resective surgery. Note gingival recession and interproximal area that resembled the underlying osseous morphology. F. Presurgical palatal view of same defect. G. Thinned palatal flap with vertical incision revealed osseous defect. H. Osseous resective surgery removed the lingual bony wall of the defect and corrected the reversed architecture by removing palatal radicular bone, giving a scalloped appearance to the osseous margin. I. Palatal flap sutured at the level of the alveolar crest. J. Six months after osseous resective surgery.

Osseous ledges. The width of the alveolar housing around a tooth is often greater in a more apical location. As the bone resorbs because of periodontitis, the osseous margin in the new apical position may be considerably thicker than in the normal periodontium, giving the appearance of a bony ledge. The alveolar margin also may be associated with an exostosis, a bony protuberance or buttressing bone, which can comprise the physiological form and periodontal maintenance of the area. This abnormally thick bony anatomy over a tooth or several teeth is thinned to a more normal width during osseous resective surgery (Fig. 9b, c). However, the thickness of the remaining bone over the root(s) is important. More osteoclastic and less osteoblastic activity occurs during the wound-healing process if the bone is too thin, resulting in more permanent loss of bone height and support (68, 92).

Alveolar bone on the facial and lingual aspects of the interproximal region is often removed, thereby creating vertical grooves or interproximal "sluiceways". In relationship to the interdental alveolus, the tooth or teeth are then in more prominence. This is to counteract the tendency for the tissue to migrate or creep coronally over the roots with time. Both thinning and interproximal grooving may also facilitate flap adaptation. However, the created sluiceways can fill in with bone during healing and remodeling (57).

The performance of osseous resective surgery requires considerable clinical judgment. The quantity and location of bone that is removed to meet the desired clinical outcomes are most important (such as eliminating intrabony pockets or providing anatomical situations that enhance maintenance of health). Yet one does not want to compromise the teeth by removing or thinning too much bone, thereby creating other periodontal problems (such as open furcations). Likewise the surgery should not diminish aesthetics or increase tooth mobility. Therefore, osseous resective surgery has clinical limitations. For example, in the case of an interproximal intrabony defect between two upper molars, the length of the radicular trunk to the distal furcation might limit the amount of ostectomy needed to remove the walls of the defect. If the ideal ostectomy would open the distal furcation, the removal of the distobuccal root or an incomplete ostectomy should be considered. A similar problem, although rare, can be found in treating an interproximal intrabony defect next to a first premolar with two roots and a short trunk. In such a situation, a resection of the palatal root, an incomplete ostectomy or an extraction of the involved tooth may be considered. The

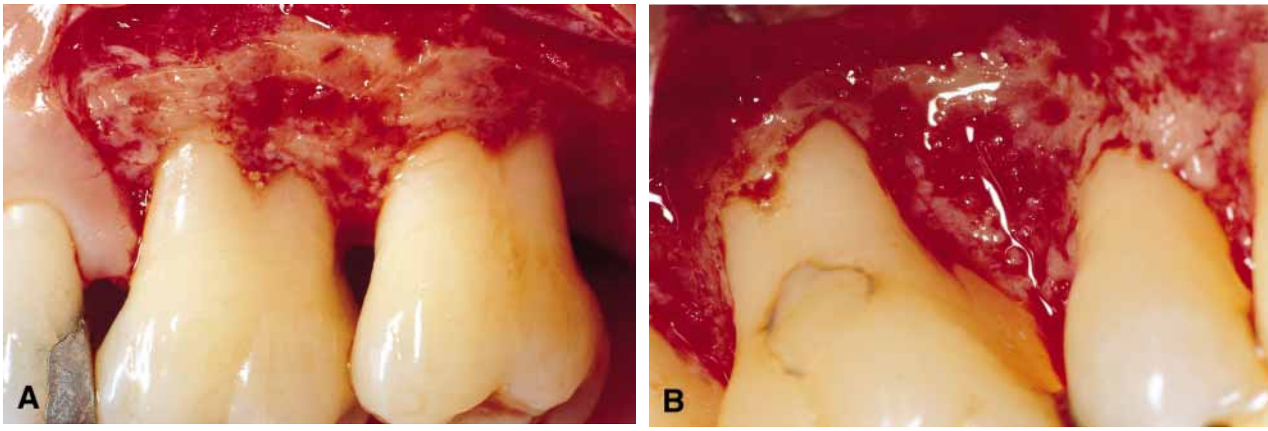


Fig. 11. Osseous resective surgery in molar furcations. Within reason, each root of a molar is considered like a single-rooted tooth, treating the furcation area like an interproximal area with osseous resective surgery. This creates a double-scalloped appearance over the molar when the furcation bone is coronal to the radicular bone and prevents the furcation from being opened. A. Buccal furcations after osseous resective surgery. B. Mesial furcation after osseous resective surgery. A double-scalloped appearance also was produced over the palatal root to diminish the amount of supporting bone removed.

other furcations of both maxillary and mandibular molars do not generally pose as many restrictions to osseous resective surgery since their locations are usually not interproximal. Within reason, each root of a molar is considered like a single tooth, and the intraradicular areas are treated like interproximal areas therefore creating a double-scalloped appearance (that is, double parabola) (Fig. 11). The severity of defects to be corrected in relation to the remaining bony support and/or their location sometimes necessitates a compromise in the bone removal from that which would provide ideal form. Partial defect elimination is then accomplished and residual pockets, albeit less deep than initially, are to be expected.

Partial ostectomy is occasionally utilized in regenerative surgical procedures. The coronal aspect of a bony wall(s) that makes up a deep intrabony defect is removed before placement of a grafting material and/or membrane. For instance, if a combination one wall–three wall intrabony defect is being treated, the one wall aspect is removed and any reversals in the bony anatomy between the facial and lingual bone in relation to the interproximal bone height are corrected. Then the graft or membrane is placed. Likewise, thick margins of bone or adjacent exostoses are thinned or removed to facilitate flap closure.

Osseous resective surgery instrumentation

Metal and coarse diamond burs in high- and low-speed handpieces, chisels, files and rongeurs have been advocated to perform osseous resective surgery. Several studies have histologically evaluated the wound-healing response in animal models when experimental defects and cuts were made utilizing various instruments. Horton et al. (39) reported that bony defects made by a chisel had a more rapid rate of healing than those made by a #557 cross-cut fissure bur in a low-speed handpiece. Costich et al. (19) compared the healing of cuts in dog mandibles made with a #558 bur in a high-speed to those made using a low-speed handpiece both with and without water irrigation. Cuts made by high-speed with irrigation had faster initial healing, which progressed more rapidly than the other cuts. However little difference existed between the four methods at the eighth week of healing. Spatz (80) reported similar early findings, with the high-speed producing less initial inflammation and more rapid recovery than the slow-speed. Moss (59) assessed the effect on the viability of the bone surrounding bur contact and found less damage adjacent to cuts made with high-speed burs as opposed to lower-speed burs. Boyne (7), in an experiment that may be considered more similar to the osseous resective surgery procedures, excised the osseous crest in dogs. He reported that at 14 days, defects made with the high-speed bur exhibited more osseous repair at the cut surfaces than those made by the low-speed bur. However, no differences were observed 6 weeks postoperatively. Calderwood et al. (12) demonstrated that cuts made by diamond burs healed extremely slow compared with high- and low-speed metal burs. The wound-healing response between the use of irrigation and no irrigation have been compared, and irrigation provided the best results (19, 26, 59).

The wound-healing dynamics of osteoclastic activity followed by osteoblastic activity are an important consideration subsequent to osseous resective surgery. The least amount of trauma to the bone is desirable for potentially more repair and less permanent damage. Adequate irrigation is a must, and factors to reduce heat are necessary. Chisels and high-speed metal burs with light pressure followed in desirability by low-speed metal burs with light pressure are preferred over the use of diamond burs. The importance of proper surgical technique in bone manipulation and the potential deleterious wound-healing effects have been refocused with the newer research in dental implant placement (9).

Osseous changes from osseous resective surgery and flap surgery

Supporting bone removed by ostectomy in human studies

The quantity of supporting bone removed by ostectomy varies according to the depth of the intrabony defect, the position of the intrabony defect, the mesio-distal width of the interproximal area, the general anatomy of the area (thin-thick) and the relative position in the dental arch (incisors-molars). These variables are not considered in the literature, and only a few studies reported on the amount of supporting bone removed by ostectomy (Table 1). Selipsky (78) demonstrated that ostectomy removed a mean of 0.6 mm of supporting bone height per tooth on a circumferential mean, with 1–2 mm of facial or lingual bone height being resected. The author implied that, even though a considerable amount of bone is removed on one surface of the tooth, the mean bone reduction per tooth is negligible. Tooth mobility also increased after surgery but gradually returned to or below the presurgical level by the end of 1 year (78). Aeschlimann et al. (1), by measuring stone models made from impressions taken on ten patients before and immediately after osseous recontouring in conjunction with apically positioned flaps, reported a mean bone height removal of 0.22 mm. Moghaddas & Stahl (57) performed osseous resective surgery in two groups of patients. The mean height of interradicular crestal bone resected after osseous resective surgery was 0.09 mm in the first group and 0.12 mm in the second group, while the mean height of radicular crestal bone resected was 0.37 mm and 0.33 mm for the two groups respectively. The mean crestal bone height resected at the furcation sites was 0.06 mm in the first group and 0.22 mm in the second group. Smith et al. (79), examining the results of "carefully defined and standardized" osseous resective surgery performed on 12 patients with moderate periodontal destruction, reported that the mean height of marginal bone removed was 1.2 mm.

The quantity of bone removed during osseous resective surgery for crown lengthing procedures performed to gain retention, adequate natural tooth exposure for a physiological gingival attachment and accessibility to otherwise deep subgingival margin preparations that hamper impression techniques, has also been studied. Bragger et al. (8) documented variable amounts of marginal bone removal by ostectomy during crown-lengthening procedures in 25 patients. One mm of crestal bone was removed at 32% of the sites, 2 mm at 21% of the sites and 3–4 mm at 4% of the sites. No change was observed at 38% of the sites and a coronal displacement of the bone level was noted at 5% of the sites, reflecting a measurement error. Carnevale & Fuzzi (14), performing osseous resective surgery in 14 patients with the objective of lengthening clinical crowns, removed a mean marginal bone height of 0.62 mm in the interproximal areas and 1.04 mm on the buccal or lingual surfaces.

In conclusion, the mean height of bone removed

Table 1. Quantity of supporting bone removed by ostectomy (mean values)

Authors	Type of surgery	Bone removed
Selipsky (78)	Osseous resective surgery	0.6 mm (circumferential)
Aeschlimann et al. (1)	Osseous resective surgery	0.22 mm
Moghaddas & Stahl (57)	Osseous resective surgery	Interradicular 0.09–0.12 mm; Radicular 0.3–0.33 mm; Furcations 0.06–0.22 mm
Smith et al. (79)	Osseous resective surgery	1.2 mm
Brägger et al. (8)	Osseous resective surgery (crown lengthening)	−1 mm 5%; 0 mm 38%; 1 mm 32%; 2 mm 21%; 3 mm 3%; 4 mm 1%
Carnevale & Fuzzi (14)	Osseous resective surgery (crown lengthening)	Interproximal 0.62 mm; Radicular 1.04 mm

during osseous resective surgery, as reported by the different authors, varied from 0.06 mm to 1.2 mm. Osseous resective surgery did not permanently alter the tooth mobility (78, 79).

Crestal bone loss from resorption after osseous resective surgery

During the wound-healing process following surgery, resorption of bone occurs and has been quantified in several studies (Table 2). By means of a surgical re-entry procedure performed 4 months after osseous resective surgery, Aeschlimann et al. (1) measured an additional mean vertical bone loss of 0.28 mm due to postsurgical remodeling. Moghaddas & Stahl (57) not only reported on the amount of bone removed with osseous resective surgery but also on the amount of remodeling of the alveolar crest in two groups of patients which were re-entered at 3 and 6 months after osseous resective surgery. After 3 months the mean height of crestal bone lost was 0.38 mm in the interradicular area, 0.84 mm in the radicular area and 0.79 mm in the furcation area. After 6 months, the mean crestal bone loss was 0.23 mm in the interradicular area, 0.55 mm in the radicular area and 0.88 mm in the furcation area. The differences between 3- and 6-month values within specific sites were not statistically significant. No significant correlation could be established between the quantity of bone resected and the amount of bone lost at each location. Smith et al. (79) assessed the bone height by sounding through gingiva to the level of supporting marginal bone 6 months after osseous resective surgery. A mean resorption of 0.2 mm of facial or lingual crestal bone and 0.3 mm of interproximal crestal bone had occurred. Bone level measurements recorded in the same group of patients 5 years later with the same technique had not changed (86). Donnenfeld et al. (22) evaluated three patients after an osteoplasty and incomplete ostectomy in conjunction with surgical flaps "that were not repositioned at the level of the alveolar bone". Measurements made immediately after the osseous surgery and at re-entry 6 months later revealed a mean interradicular bone loss of 0.6 mm and a mean radicular bone loss of 1 mm.

Pennel et al. (68) and Wilderman et al. (92) reported on both the clinical and histological wound healing in the same group of patients following a buccal osteoplasty and ostectomy. A gingival mucoperiosteal flap was elevated followed by an osteoplasty on 5 mm of marginal bone and an ostectomy of approximately 1 mm of crestal bone. The experimental area was confined to the vestibular alveolar process over the root of the test tooth. Following osseous resective surgery, the gingival flap was positioned to cover the alveolar process and 1–2 mm of root surface. Pennel et al. (68) reported on the crestal bone resorption. Measurements of 34 teeth from 20 patients were obtained using standardized photographs with postsurgical healing intervals ranging from 14 to 545 days. The average posthealing reduction of the alveolar crest was 0.54 mm. A total of 28 teeth (82%) showed less than 1 mm of bone loss, of which 16 teeth (47%) demonstrated no measurable loss. Only 2 teeth that had thin bone demonstrated

Table 2. Crestal bone lost from resorption during healing after flap elevation with or without osseous resective surgery (numerical data are mean values)

Authors	Type of study	Full-thickness flap	Partial-thickness flap	Full-thickness flap+ osseous resective surgery
Kohler & Ramfjord (48)	Clinical+histological	None		
Friedman & Levine (30)	Clinical+histological	None		0.25–0.3 mm
Felts & McKenzie (25)	Clinical	Minimal		Minimal
Donnenfeld et al. (21)	Clinical	0.63 mm		
Pfeiffer (69)	Histological	Little osteoclastic activity	Very little osteoclastic activity	
Pennel et al. (68)	Clinical			0.54 mm
Donnenfeld et al. (22)	Clinical			0.6–1 mm
Wilderman (92)	Histological			0.8 mm
Wood et al. (93)	Clinical	0.62 mm	0.98 mm	
Aeschlimann et al. (1)	Clinical	0.16 mm		0.28 mm
Moghaddas & Stahl (57)	Clinical			0.23–0.88 mm
Smith et al. (79)	Clinical	0.2 mm		0.2–0.3 mm

significant loss, 3.0 and 3.8 mm respectively (68). Twenty-three of these experimental teeth were removed in block section and studied histologically by Wilderman et al. (92). Necrosis occurred in the bone immediately below the reduced periosteal surface where the osteoplasty was performed. Resorption first occurred on the periodontal ligament side if the vestibular plate of bone was thin and on the bone surfaces within the marrow spaces if the bone plate was thicker. The resorption on the surgically reduced periosteal bone surface was delayed and occurred between two and three weeks of healing. Osteoblastic activity followed and reached its peak between the third and fourth week after surgery with very little additional apposition by 6 months. After healing of this experimental procedure the mean loss of alveolar crestal bone in 14 specimens was 0.8 mm, although a few specimens that had thin bone exhibited up to 3.1 mm loss of crestal bone. Maximum bone repair and almost complete anatomical restoration with no permanent loss of the operated bone as achieved if the preoperative bone was the thick cancellous type with many marrow spaces.

The clinical and histological investigations do not address the level of the connective tissue attachment before and after osseous resective surgery. The question of whether the observed bone resorption during the wound-healing process corresponds to an equal connective tissue attachment loss remains.

Remodeling of nonsupporting bone after osseous resective surgery

The quantity of bone remodeling after osseous resective surgery has not been reported, but there is a general agreement that thin bone is more affected than thick bone (57, 68, 92). Pennel et al. (68) stated that "in patients where the alveolar bone was initially classified as thin, osseous reduction rendered the bone far thinner than would be necessary or desirable in a therapeutic procedure". Wilderman et al. (92) also stated, "microscopic evidence indicated that more bone loss and less bone repair occurred in the thin alveolar bone specimens while the reverse was true in the thick alveolar bone specimens". Moghaddas et al. (57) concluded from the comparison of study casts made from impressions taken immediately after osseous resective surgery and after re-entry procedures, "the recontoured alveolar bone was further remodeled in favor of more scalloping. Interradicular sluiceways which initially were prepared to establish a parabolic architecture underwent subsequent alveolar bone remodeling, resulting in a smooth surface or buttressing bone formation. Thinning of alveolar bone was observed primarily at radicular alveolar bone surfaces".

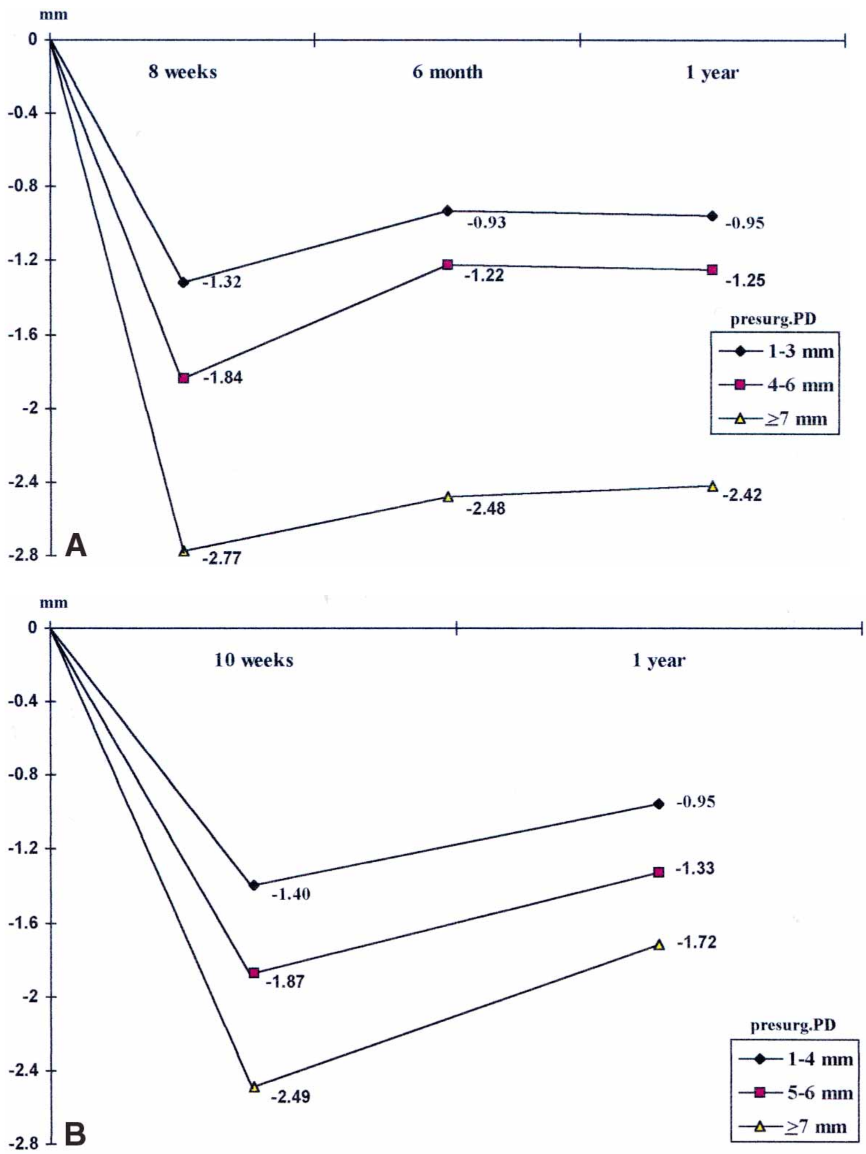
Bone loss and remodeling after flap elevation without osseous resective surgery

The bone loss and remodeling reported above is not caused solely by the direct surgical trauma from the osseous resective surgery. Clinical and histological wound-healing studies performed after surgical flap elevation that did not entail osseous resective surgery have been done (Table 2). The quantities of supporting bone loss and remodeling that have been reported range from no resorption to 0.8 mm loss of supporting bone (1, 21, 22, 25, 30, 48, 79, 91). Differences in the wound-healing response between full thickness and partial thickness mucoperiosteal flaps have been reported, with neither having a clear clinical advantage over the other (69, 93).

Soft tissue response to osseous resective surgery

Several aspects of the gingival response to osseous resective surgery, including changes in probing depth, clinical attachment level and postsurgical gingival recession as well as the postoperative topography, have been reported in clinical trials that documented the immediate response and subsequent short-term dynamic changes for up to 6 months to 1 year following surgery (5, 8, 14, 40). Treatment of periodontal disease often results in gingival recession (51). The amount of recession that follows osseous resective surgery is directly proportional to the severity of the presurgical probing depths on the buccal, lingual and interproximal surfaces (5, 40, 51, 79). The magnitude of recession immediately following osseous resective surgery decreases some during the first postoperative year with a coronal shift of the gingival margin.

Becker et al. (5) reported that the mean recession in 16 periodontal patients following osseous resective surgery in 1- to 3-mm probing depth sites was 1.32 mm at 8 weeks postsurgery, 0.93 mm at 6 months and 0.95 mm at 1 year postsurgery. In 4- to 6-mm sites the recession was 1.84 mm at 8 weeks, 1.22 mm at 6 months and 1.25 mm at 1 year postsurgery, while in ≥7 mm probing depths the mean recession was 2.77 mm at 8 weeks postsurgery, 2.48 mm at 6 months and 2.42 mm after 1 year (Fig. 12a). Kaldahl et al. (40) reported on the mean change in



gingival recession in 82 periodontal patients. Following the nonsurgical phase of treatment, in 1- to 4-mm presurgical probing depth sites osseous resective surgery created 1.40 mm of recession 10 weeks postsurgery, which decreased to 0.95 mm at 1 year; 1.87 mm recession was created after 10 weeks, which decreased to 1.33 mm at 1 year in 5- to 6-mm presurgical depths; 2.49 mm recession was created after 10 weeks which decreased to 1.72 mm after 1 year in ≥7 mm presurgical probing depths (Fig. 12b).

Brägger et al. (8) documented the soft tissue changes over a 6-month healing period following osseous resective surgery to lengthen the clinical crowns for restorative reasons in 25 patients (Fig. 12c). The mean recession created was 1.3 mm immediately after suturing, 1.5 mm at 6 postoperative weeks and 1.4 mm at 6 months. Camevale & Fuzzi (14) described the effect of osseous resective surgery for crown lengthening in 14 patients during 6 months of healing (Fig. 12d). In the interproximal areas the mean recession was 2.08 mm at 15 postoperative days, 1.67 mm at 30 days, 1.39 mm at 90 days and 0.87 at 180 days. In the buccal and lingual areas the mean recession was 2.21 mm at 15 days following surgery, 2.13 mm at 30 days, 1.94 mm at 90 days and 1.69 mm at 180 days.

Osseous resective surgery has been shown to significantly decrease probing depths, with the magnitude of decrease declining longitudinally over time but never reaching preoperative levels. Becker et al. (5) reported that in 1- to 3-mm probing depth sites, the mean probing depth was 2.39 mm before surgery, 1.63 mm 8 weeks after osseous resective surgery, 2.10 mm after 6 months and 2.24 mm after 1 year. In 4- to

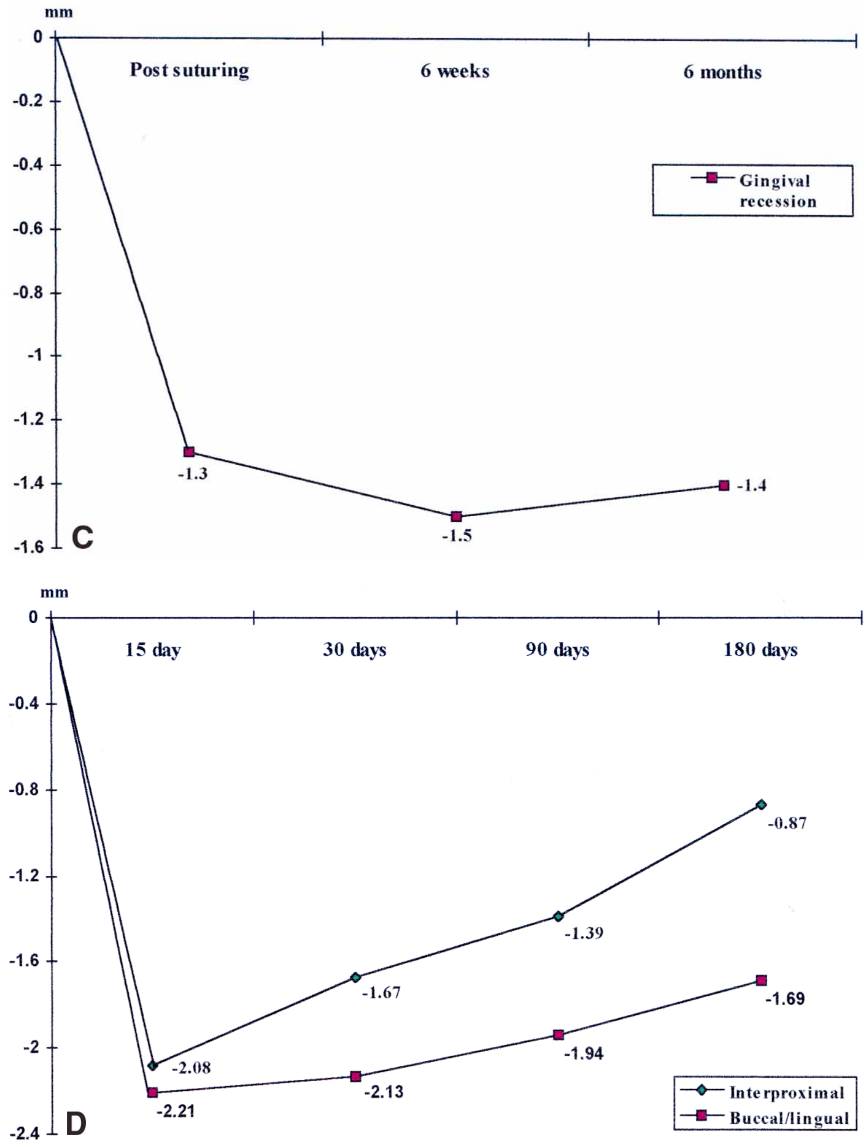
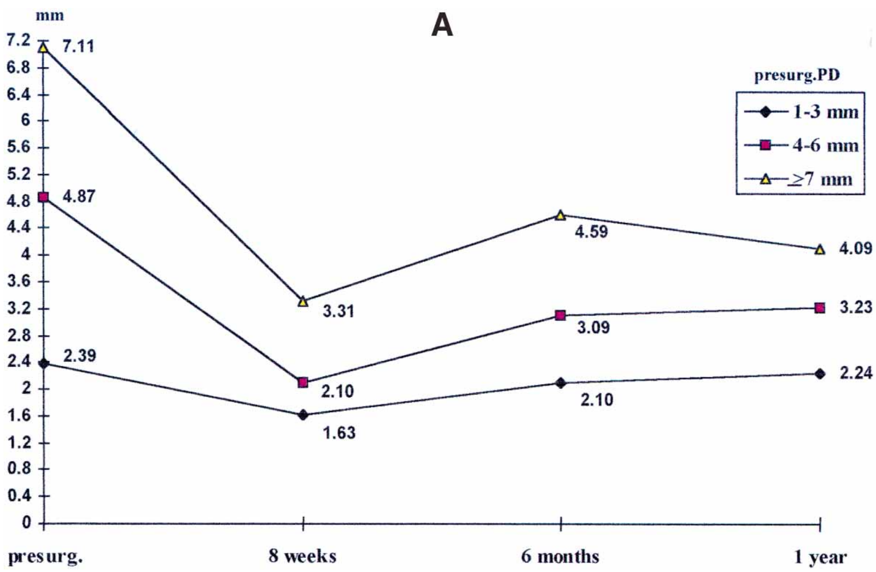


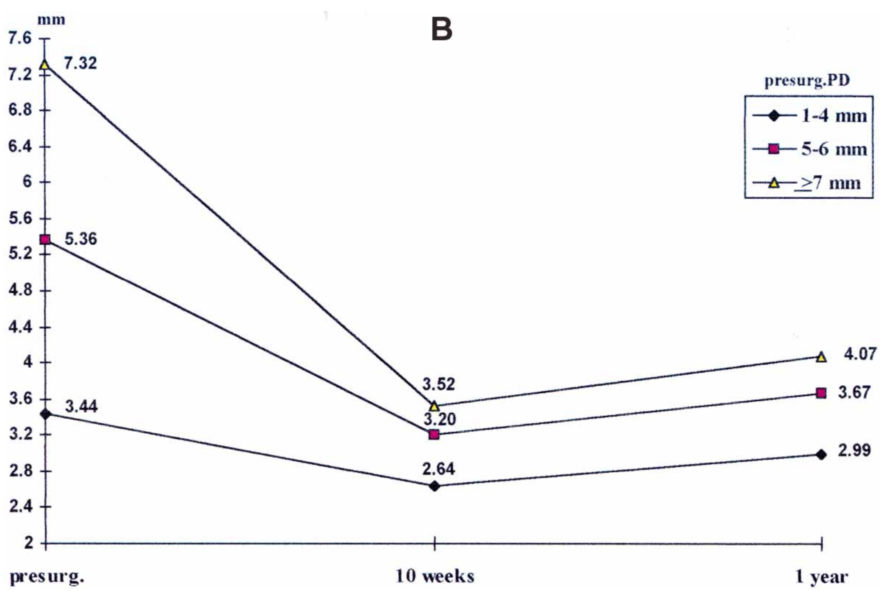
Fig. 12. Mean variations in recession values after osseous resective surgery. A. According to Becker et al. (5). B. According to Kaldahl et al. (40). C. For crown lengthening according to Brägger et al. (8). D. For crown lengthening according to Carnevale & Fuzzi (14). PD: probing depth.

6-mm sites, the mean probing depth was 4.87 mm before surgery, 2.10 mm 8 weeks after osseous resective surgery, 3.09 mm after 6 months and 3.23 mm after 1 year. In ≥7 mm probing depth sites, the mean probing depth was 7.1 1 mm before surgery, 3.31 mm 8 weeks after osseous resective surgery, 4.59 mm after 6 months and 4.09 mm after 1 year (Fig. 13). Kaldahl et al. (40), following the nonsurgical phase of treatment, reported that the mean probing depth in the 1- to 4-mm presurgical probing depth sites was 2.64 mm 10 weeks after osseous resective surgery and 2.99 mm after 1 year; in the presurgical 5- to 6-mm sites the probing depth was 3.20 mm 10 weeks after osseous resective surgery and 3.67 mm after 1 year; in the presurgical ≥7 mm probing depth sites, the mean probing depth was 3.52 mm 10 weeks after osseous resective surgery and 4.07 mm after 1 year (Fig. 13b).

Brägger et al. (8) reported that the mean probing depth was 1.89 mm before the osseous resective surgery for crown lengthening, 2.13 mm after 6 weeks and 2.24 mm after 6 months of healing (Fig. 13c). Carnevale & Fuzzi (14) reported on the mean probing depth following osseous resective surgery for lengthening the crown. The mean presurgical interproximal probing depth was 2.92 mm, 1.61 mm after 15 days, 1.59 mm after 30 days, 1.79 mm after 60 days and 1.92 mm after 180 days of healing. In the buccal and lingual areas, the mean probing depth was 2.27 mm before osseous resective surgery, 1.25 mm after 15 days, 1.23 mm after 30 days, 1.44 mm after 90 days and 1.39 mm after 180 days of healing (Fig. 13d).

The changes in the clinical attachment levels immediately following osseous resective surgery and





up to 1 year have been documented. Becker et al. (5) reported that in 1- to 3-mm probing depth sites at base line, the mean clinical attachment loss was 0.57 mm 8 weeks after osseous resective surgery, 0.64 mm after 6 months and 0.81 mm after 1 year; in 4- to 6- mm probing depth sites at baseline, the clinical attachment gain was 0.92 mm 8 weeks following osseous resective surgery, 0.56 mm after 6 months and 0.38 mm after 1 year; in initial ≥7 mm probing depth sites, the clinical attachment gain was 1.02 mm after 8 weeks following osseous resective surgery, 0.03 mm after 6 months and 0.59 mm after 1 year (Fig. 14a). Kaldahl et al. (40), after the nonsurgical phase of treatment, reported that the mean clinical attachment loss following osseous resective surgery in the presurgical 1- to 4-mm probing depth sites was 0.60 mm after 10 postoperative weeks and 0.50 mm after 1 year. The mean clinical attachment gain in presurgical 5- to 6-mm sites was 0.29 mm 10 weeks after osseous resective surgery and 0.36 mm after 1 year; the gain in presurgical ≥7 mm probing depth sites was 1.31 mm 10 weeks after osseous resective surgery and 1.53 mm after 1 year (Fig. 14b).

The changes in the clinical attachment levels following osseous resective surgery for crown lengthening have been studied. Bragger et al. (8) documented a mean attachment loss of 1.44 mm after 6 weeks and of 1.36 mm after 6 months of healing (Fig. 14c). Carnevale & Fuzzi (14) reported that in the 14 interproximal areas, the mean clinical attachment loss was 0.87 mm at 15 days, 0.35 mm at 30 days, 0.25 mm at 90 days of healing and a probing attachment

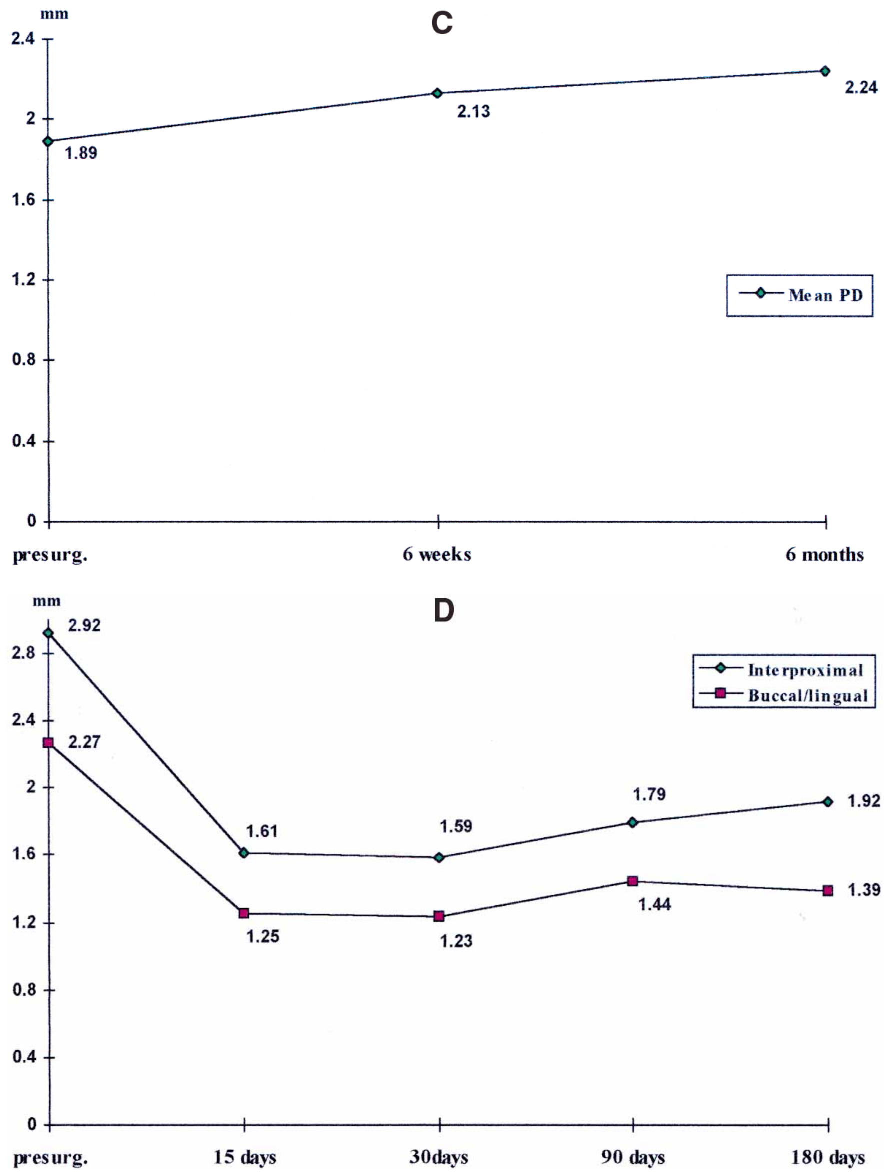


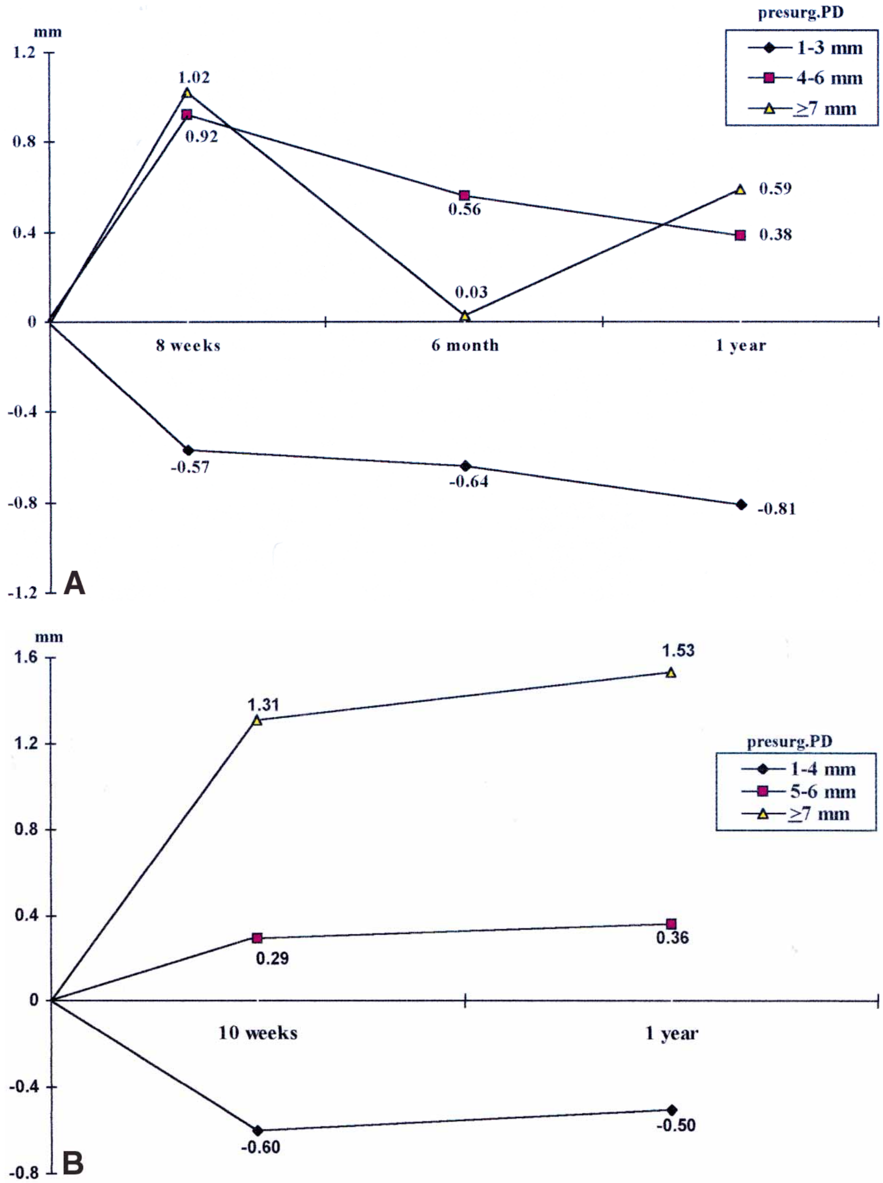
Fig. 13. Mean probing depth values after osseous resective surgery. A. According to Becker et al. (5). B. According to Kaldahl et al. (40). C. For crown lengthening according to Brägger et al. (8). D. For crown lengthening according to Carnevale & Fuzzi (14). PD: probing depth.

gain of 0.13 mm after 180 days. In the buccal and lingual areas the mean clinical attachment level loss was 1.19 mm after 15 days, 1.09 mm after 30 days, 1.11 mm after 90 days and 0.81 mm after 180 days of healing (Fig. 14d).

In summary, the new gingival relationship to the tooth immediately after osseous resective surgery is dynamic and experiences short-term changes. A coronal shift of the gingival margin and a change of the clinical attachment level resulting in an increase of probing depth have been noted when the immediate postsurgical data are compared with data 6 months or 1 year later (5, 14, 40).

In reviewing these studies, it is interesting to note that the deeper sites had a gain in probing attachment level from a procedure (osseous resective surgery) that is usually not thought of as producing a gain. Osseous surgery is not primarily performed in the deep portions of the osseous defects corresponding to the deeper probing depths. The gain is primarily from the resolution of inflammation with the reorganization of the gingival connective tissue, thereby decreasing the probe penetration between the initial and postoperative examinations (27).

In comparing the studies by Bragger et al. (8) to Carnevale & Fuzzi (14) where osseous resective surgery was used for crown lengthening, differences can be observed in all the examined clinical parameters. Bragger has an unusual soft tissue healing because mean recession, probing depth and probing attachment level did not change from 6 postoperative weeks to 6 months and postsurgical probing



depth values were deeper than the presurgical ones. Carnevale, conversely, showed data similar to Becker et al. (5) and Kaldahl et al. (40) that included some coronal regrowth of the gingival margin and a minimal increase in probing depths values between 15 days and 6 months of healing. A probing attachment level loss was maintained for 6 postoperative months in the radicular areas while it returned to the presurgical level in the interproximal sites. At the sixth postoperative month, both studies demonstrated a mean lengthening of the clinical crowns of more than 1 mm.

Becker et al. (5) described the occurrence of soft tissue interproximal craters following osseous resective surgery in 16 periodontal patients. Fifty-seven percent of the sites had soft tissue cratering after surgery but only 3% had craters after the fifth postoperative week. The authors' explanation was that complete interproximnal flap closure was not achieved following osseous resective surgery.

With adequate time for healing and maturation succeeding osseous resective surgery, the gingival topography is also affected by other factors such as underlying bone contours, tooth position, crown and root form, interproximal distance between roots and embrasure spaces. For example, the gingiva is more likely to proliferate coronally in a narrower interproximal space. Smith et al. (79) documented that, after osseous resective surgery, the gingiva was placed in a more apical position and therefore

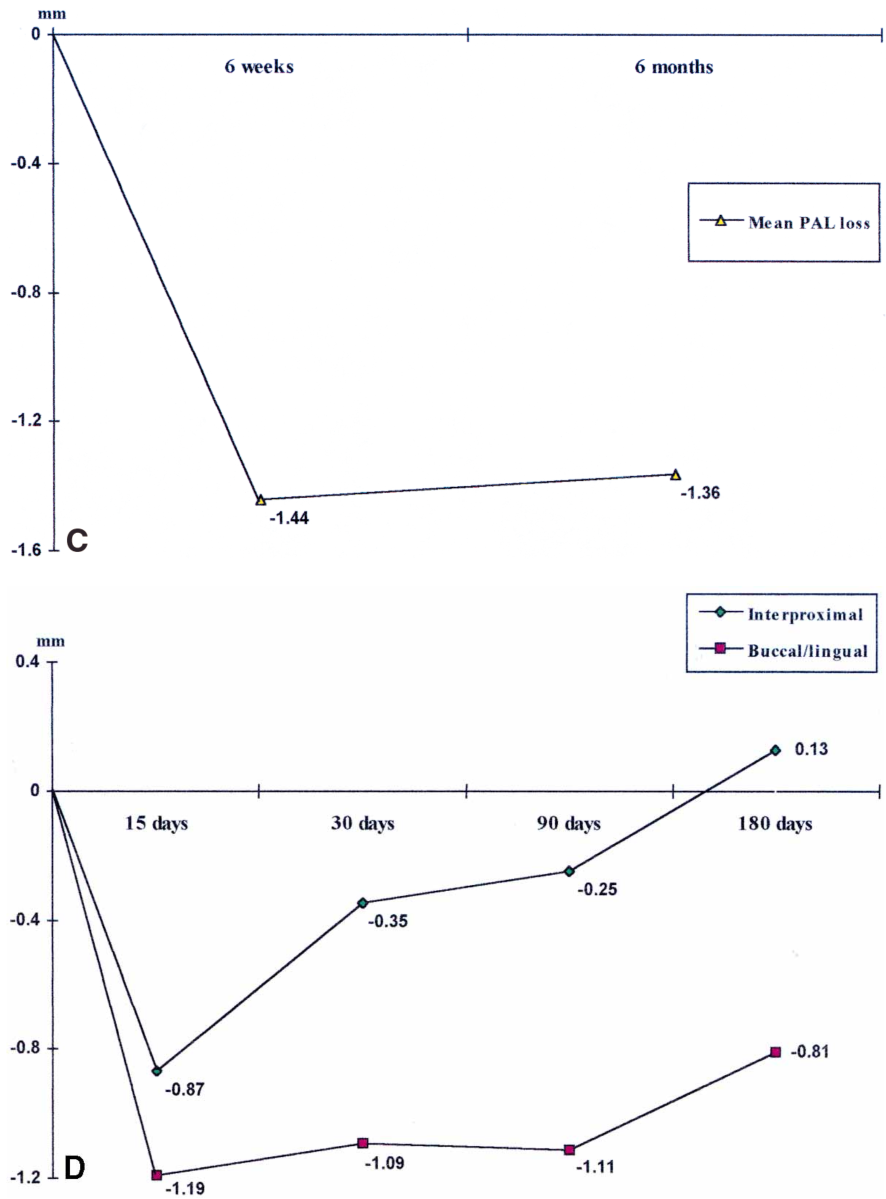


Fig. 14. Mean variations in probing attachment levels (PAL) after osseous resective surgery. A. According to Becker et al. (5). B. According to Kaldahl et al. (40). C. For crown lengthening according to Brägger et al. (8). D. For crown lengthening according to Carnevale & Fuzzi (14). PD: probing depth.

healed in an embrasure space that was more open than in flapped areas without osseous resective surgery. In time the gingival tissues had more coronal proliferation in the less open embrasure areas that had only been flapped (79). Individual patients also have a genetic predisposition to the thickness and morphology of their gingival tissues that will affect the amount of rebound (65). When the gingival margin is removed, older individuals tend to have less rebound than younger individuals (38).

The patient's plaque control effectiveness is an important factor in the healing and periodontal stability following osseous resective surgery. Rosling et al. (76) and Nyman et al. (61) demonstrated that, following surgical therapy with osseous recontouring, patients with good plaque control effectiveness and regular supportive periodontal therapy were stable. Patients who had poor plaque control and lacked good supportive periodontal therapy had increased probing depths and further loss of attachment over a 2-year postsurgical period.

In summary, the probing depths, clinical attachment levels, gingival margin locations and gingival tissue contours obtained in the immediate posthealing phase after osseous resective surgery will change over time. However, it has been shown long term (5 or 7 years) that these changes are not likely to reach the pretreatment levels (43, 86).

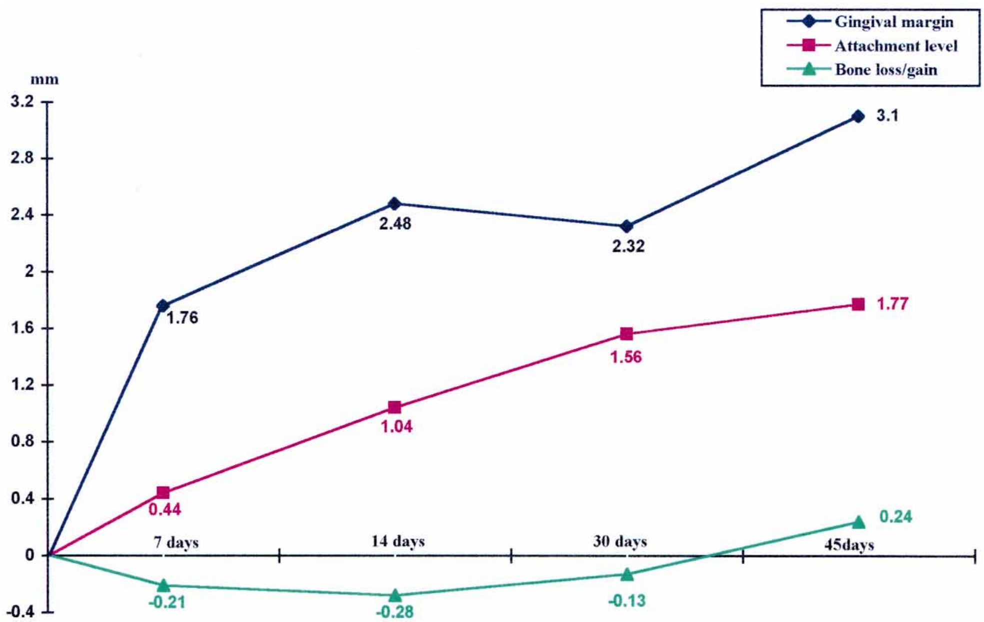


Fig. 15. Early histological healing in dogs after buccal ostectomy (20)

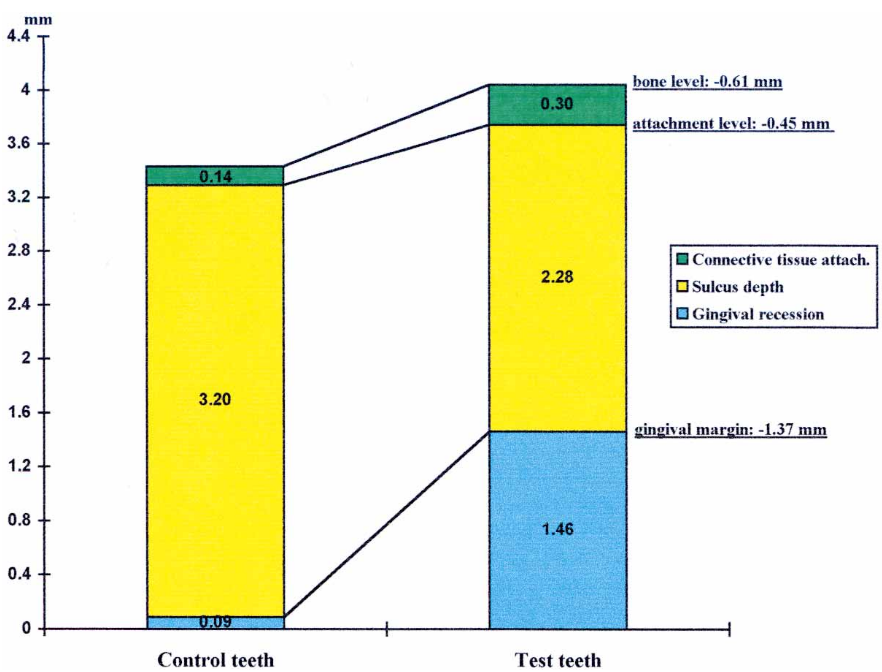


Fig. 16. Differences in interproximal periodontal soft tissue levels between non-operated control teeth and test teeth 1 year after osseous resective surgery (16)

Studies of osseous resective surgery in animals

Lobene & Glickman (54) described the histological alterations of the buccal alveolar bone in four dogs after a marginal gingivectomy and mucoperiosteal flap with and without bone reduction utilizing a rotary diamond stone. Little, if any, reduction in crestal height was noted in the 7- and 14-day specimens. In the 21- and 28-day specimens, sites treated with osseous resective surgery had a buccal alveolar bone height loss of 0 to 1.7 mm, and the specimens that did not have osseous resective surgery had a bone loss of 0 to 0.5 mm. Contrary results were reported by De Sanctis et al. (20). A mucoperiosteal flap was elevated and an ostectomy removed up to 5 mm of buccal bone from the cementoenamel junction in dogs. In the 45-day histological specimens, a mean postsurgical bone gain of 0.24 mm had occurred. During the healing process, a coronal shift of the connective and epithelial attachment was also measured (Fig. 15).

As part of a series of studies performed for the histometric evaluation of periodontal surgery, Caton & Nyman (16) analyzed the effect of surgical elimination of the osseous walls of interproximal angular bony defects on the connective tissue attachment and the alveolar bone level in four Rhesus monkeys. In the 1-year postoperative specimens, the comparisons of the 36 surgical test teeth to the 36 non-operated control teeth revealed that the surgically treated teeth had a significant mean loss of connective tissue attachment and crestal bone height and a more apical location of the junctional epithelium and gingival margin (Fig. 16). A significant decrease of the sulcus depth occurred as a result of the elimination of the angular osseous defects. Because adjacent teeth were involved with the osseous resective surgery, they experienced a significant loss of support (that is, bone loss of 1.13 mm and connective tissue attachment loss of 1.34 mm) (16).

Matherson (56) published a macroscopic and microscopic investigation undertaken to determine the maintenance of surgically produced osseous contours after approximately 2 mm of bone height removal with osseous resective surgery in three rhesus monkeys. The influence of the resultant bony profile on the overlying soft tissue morphology was also reported. The maintained reduction of crestal bone height after 6 months of healing was 0.6–1.3 mm and the recession of the gingival margin was 0.2–1.4 mm in various areas of the mouth. Following osseous resective surgery, the soft tissue contours reflected the underlying osseous contours when there was sufficiently large interproximal space. In these areas, the peaks of the col were eliminated because of increased distance from the dental contact to the gingiva and the gingiva conformed to the bone. These results are similar to those reported on humans by Smith et al. (79).

Comparison of osseous resective surgery with other periodontal therapies

Several studies have compared the short-term clinical effects of osseous resective surgery with those of other nonsurgical and surgical therapies while a few have reported on the long-term (≥5 years) results (42). With the emphasis today on the long term effectiveness of therapy, the following review will focus only on the longitudinal clinical trials that compared osseous resective surgery to one or more therapies for five or more years (Tables 3 and 4). Supportive periodontal therapy followed the active nonsurgical and surgical therapy in all the studies. Ramfjord and coworkers were the first to prospectively compare the clinical results following nonsurgical and surgical periodontal therapy on a large group of patients over an extended period of time (72).

Knowles et al. (47) reported data from patients treated in a split mouth design with gingival curettage, pocket elimination surgery (osseous resective surgery) and modified Widman surgery. Seventy-two patients completed 5 years of supportive periodontal therapy. In initial pockets of 1–3 mm, the amount of change in probing depth was minimal and a slight loss of clinical attachment had occurred with the change for each parameter being similar for all therapies. In initial pockets of 4–6 mm, sites treated with osseous resective surgery still had more reduction of probing depth after 5 years than sites treated by

Table 3. Clinical trials that compared probing depth reduction by osseous resective surgery to flap surgery without osseous resective surgery or nonsurgical therapy 5 years after treatment (≥4 mm probing sites)

Osseous resective surgery versus flap surgery		Osseous resective surgery versus root planing or curettage	
Osseous resective surgery → greater reduction	**No difference**	**Osseous resective surgery → greater reduction**	**No difference**
	Knowles et al. (47)	Knowles et al. (47) (4–6 mm sites)	Knowles et al. (47) (≥7 mm sites)
	Rosling (75)		
Townsend-Olsen et al. (86)			
	Ramfjord et al. (74)		Ramfjord et al. (74)
	Kerry et al. (46)		Kerry et al. (46)
Kaldahl et al. (43)		Kaldahl et al. (43)	

Table 4. Clinical trials that compared clinical attachment change by osseous resective surgery to flap surgery without osseous resective surgery or nonsurgical therapy 5 years after treatment (≥4 mm probing sites)

Osseous resective surgery versus flap surgery		Osseous resective surgery versus root planing or curettage	
Flap surgery → greater gain	**No difference**	**Root planing or curettage → greater gain**	**No difference**
Knowles et al. (47) (≥7 mm sites)	Knowles et al. (47) (4–6 mm sites)		Knowles et al. (47)
Rosling (75)			
Townsend-Olsen et al. (86)			
	Ramfjord et al. (74)	Ramfjord et al. (74) (4–6 mm sites)	Ramfjord et al. (74) (≥7 mm sites)
	Becker et al. (4)		Becker et al. (4)
	Kaldahl et al. (43)	Kaldahl et al. (43) (5–6 mm sites)	Kaldahl et al. (43) (≥7 mm sites)

curettage, but there was no difference between sites treated by osseous resective surgery and modified Widman surgery. The amount of clinical attachment level gain was similar for all three therapies. In initial pockets of ≥7 mm, no difference existed between the therapies in probing reduction. There was no difference in the clinical attachment gain between osseous resective surgery and curettage, but the modified Widman surgery had created a greater gain than osseous resective surgery. In both the 4–6 mm and ≥7 mm categories, the initial pocket depth reduction was significant and, although the magnitude decreased partially during supportive periodontal therapy, it was still clinically significant after 5 years.

A second clinical study from the same group compared root planing, modified Widman surgery and pocket elimination surgery (osseous resective surgery). Ramfiord et al. (74) reported the results after 5 years of supportive periodontal therapy. In 72 patients with initial pockets of 1–3 mm, osseous resective surgery had produced significantly greater reduction in mean probing depth than root planing and modified Widman after the first year of supportive periodontal therapy (osseous resective surgery=−0.47 mm, modified Widman=−0.34 mm, root planing −0.17 mm). After 5 years, some recurrence of pocketing had occurred resulting in no significant difference between treatments (osseous resective surgery=−0.003 mm, modified Widman=−0.15 mm, root planing=−0.14 mm). After year one of supportive periodontal therapy, all therapies had produced a loss of mean probing attachment values, with osseous resective surgery being significantly greater than root planing (osseous resective surgery=−0.64 mm, modified Widman surgery=−0.58 mm, root planing=−0.27 mm). After five years, a further loss of mean probing attachment values of approximately 0.5 mm had occurred (osseous resective surgery=−1.17 mm, modified Widman=−1.12 mm and root planing=−0.89 mm). Osseous resective surgery was statistically different from root planing. In initial pockets of 4–6 mm, osseous resective surgery produced greater reduction in probing depth after 1 year (osseous resective surgery=−1.81 mm, modified Widman=−1.54 mm, root planing=−1.26 mm). Some recurrence in probing depth occurred by year 5 in 72 patients such that no statistical differences were present between osseous resective surgery and the other two therapies in the amount of pocket reduction (osseous resective surgery=−1.29 mm, modified Widman=−1.15 mm, root planing=−1.08 mm). After year 1, root planing had produced a gain of probing attachment of 0.25 mm, and the surgery had produced a loss (osseous resective surgery=−0.22 mm, modified Widman=−0.11 mm). After the fifth year, a further loss of mean probing attachment of approximately 0.5 mm had occurred, resulting in osseous resective surgery being statistically different from root planing (osseous resective surgery=−0.71 mm modified Widman=−0.54 mm and root planing=−0.32 mm). After the first year of supportive periodontal therapy, sites treated by osseous resective surgery had a significantly greater reduction in probing depth than sites treated by root planing (osseous resective surgery=−4.17 mm, modified Widman=−3.41 mm, root planing=−2.85 mm) in the ≥7 mm probing depths. After the fifth year of supportive periodontal therapy, the number of patient's quadrants that were treated by the various therapies in pockets initially ≥7 mm varied between 26 and 28. No statistical differences existed between the mean changes in probing depth created by the three therapies at year 5 (osseous resective surgery=−3.53 mm, modified Widman=−3.13 mm, root planing=−2.92 mm). After year 1, all three therapies produced a gain in clinical attachment level, with no statistical differences (osseous resective surgery=0.69 mm, modified Widman=1.16 mm, root planing=0.99 mm). After year 5 of supportive periodontal therapy, some loss of previously gained probing attachment occurred with the loss in sites treated by modified Widman and root planing being twice that for osseous resective surgery. No statistical difference between the three therapies existed (osseous resective surgery= 0.43 mm, modified Widman=0.63 mm, root planing=0.59 mm). No molar furcations were included (74).

Rosling et al. (75, 76) reported on the comparison of treating ten patients each with apically positioned flap with osseous resection (osseous resective surgery), apically positioned flap without osseous resection, Widman flap with osseous resection, Widman flap without osseous resection and gingivectomy. No difference between the surgical procedures occurred in the amount of probing depth reduction following 2 years of supportive periodontal therapy. Sites treated by osseous surgery had less probing attachment gain or more loss than sites that did not receive osseous surgery. A subsequent publication on the results after 6 years did not present any data but reported that no changes occurred during that extended period and the relative results were the same as the two year report. The only molar site included in this study was the mesial of the first mandibular molars (75, 76).

Smith et al. (79) compared the apically positioned flap surgery to apically positioned flap with osseous recontouring (osseous resective surgery) in a split mouth design on 12 patients. No difference in the amount of probing depth reduction by the two procedures was present 6 months following therapy. Longitudinally, more recurrence of probing depth occurred in sites treated by apically positioned flap without osseous resective surgery than with osseous resective surgery. The sites treated with osseous resective surgery had greater reduction of probing depth in the 5-year report of 8 patients (86). The clinical attachment level sites treated by osseous resective surgery was significantly more apical at the 5-year examination (3.9 mm versus 3.5 mm) (86).

Becker et al. (5) reported on the 1-year results that compared root planing, modified Widman surgery and flap with osseous resective surgery in a split-mouth design on 16 patients in a private practice setting. To date the 5-year results have only been reported in abstract form (4, 46). Following 1 year, the sites treated by osseous resective surgery had a statistically greater reduction in probing depth than sites treated by root planing in initial pocket depths of 4–6 mm and ≥7 mm. Osseous resective surgery also produced greater loss of clinical attachment level than root planing in the initial 1- to 3-mm sites. No differences existed, with all procedures having had similar impact on the probing depths and clinical attachment levels after 5 years (4, 46).

Kaldahl et al. (40, 43) compared root planing, modified Widman surgery and flap with osseous resective surgery in a split-mouth design. Seventy-two patients completed year 5 of supportive periodontal therapy. In initial pockets of 1–4 mm, following one year of supportive periodontal therapy, osseous resective surgery had produced a greater reduction in mean probing depth than root planing but by year 5, no difference existed. Osseous resective surgery produced a loss of mean probing attachment level in these shallow sites at year 1 that was statistically different from modified Widman and root planing (osseous resective surgery=−0.59 mm, modified Widman=0.02 mm, root planing=0.26 mm). This relationship was sustained through year 5 (osseous resective surgery=−0.73 mm, modified Widman= −0.41 mm, root planing=−0.12 mm). In the initial pockets of 5–6 mm, at year 1 the sites treated by osseous resective surgery had greater reduction in mean probing depth (osseous resective surgery=−1.96 mm, modified Widman=−1.60 mm, root planing= −1.36 mm). By year 5, the sites treated by osseous resective surgery still had significantly greater reduction in probing depth than by modified Widman and root planing (osseous resective surgery=−1.85 mm, modified Widman=−1.48 mm, root planing=−1.52 mm). The gain in mean clinical attachment levels at year 1 in sites treated by osseous resective surgery were less than for root planing and modified Widman (osseous resective surgery=0.48 mm, modified Widman=0.92 mm, root planing=1.09 mm). At year 5, the gain in the osseous resective surgery sites was still statistically less than in those sites treated by root planing but not by modified Widman (osseous resective surgery=0.44 mm, modified Widman=0.60 mm, root planing=0.90 mm). In the initial pockets of ≥7 mm, osseous resective surgery produced greater reduction in probing depth than modified Widman or root planing (osseous resective surgery=−3.68 mm, modified Widman=−2.95 mm, root planing= −2.39 mm). This relationship held true through year 5 (osseous resective surgery=−3.38 mm, modified


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Fig. 17. Long-term case report. A. Pretreatment view with initial 5–9 mm interproximal probings in the mandibular right posterior segment. B. Interproximal craters exposed after flap reflection. C. After osseous resective surgery bone level in furcation was coronal to radicular bone. D. Flap sutured. E. One year after osseous resective surgery with 2–3 mm interproximal probings. F. Eighteen years after osseous resective surgery with 4-mm interproximal probings. Some coronal movement of the gingival margin has occurred. G. Pretreatment view with initial 5- to 9-mm interproximal probings on the lingual. H. Osseous defects exposed. I. After osseous resective surgery. J. Flap sutured. K. One year after osseous resective surgery with 2- to 3-mm interproximal probings. L. Eighteen years after osseous resective surgery with generalized 3- to 4-mm interproximal probings and one 5-mm probing on the mesial of the second molar. Some coronal movement of the gingival margin has occurred. M. Pretreatment radiograph. N. Radiograph 18 years after osseous resective surgery.

Widman=−3.09 mm, root planing=−2.88 mm). The clinical attachment level gains were similar, with no statistical differences between all three therapies both at year one (osseous resective surgery=1.83 mm, modified Widman=2.07 mm, root planing=1.88 mm) and at year 5 (osseous resective surgery=1.76 mm, modified Widman=1.92 mm, root planing=1.93 mm) (43).

Table 5. Yearly incidence of sites losing ≥3 mm of clinical attachment during 7 years of supportive periodontal therapy following three treatment modalities. Probing severity categorized at the initial exam.
Source: Kaldahl et al. (44), with permission

Category		Root plane	Modified Widman	Flap and osseous
1–4 mm	%	0.63%	0.70%	0.29%
	n	9383	6439	5549
5–6 mm	%	1.94%	1.72%	0.94%
	n	5786	5156	4685
≥7 mm	%	3.19%	2.09%	1.36%
	n	2981	2967	2494

] or ⌐¬ =significant difference ($P<0.05$).

Table 6. Yearly incidence of sites losing ≥3 mm of clinical attachment during 7 years of supportive periodontal therapy following three treatment modalities. Probing severity categorized 10 weeks after surgery therapy.
Source: Kaldahl et al. (44), with permission

Category		Root plane	Modified Widman	Flap and osseous
1–4 mm	%	1.08%	1.22%	0.70%
	n	13,903	12,391	12,355
5–6 mm	%	1.20%	1.91%	1.34%
	n	3271	1933	373
≥7 mm	%	4.10%	3.78%	– – –
	n	976	238	

] or ⌐¬ =significant difference ($P<0.05$).

Some general assessments are in order when considering the results from the clinical studies. The actual depths of the intrabony and hemiseptal osseous defects are not given and the indications and contraindications for the use of osseous resective surgery are therefore difficult to assess. An 8-mm probing depth might correspond to a 2-mm or a 5-mm intrabony component in which only the first case is ideally amenable for osseous resective surgery treatment. Comparing and analyzing clinical situations where a surgical technique might or might not be indicated can cloud the information's usefulness. The lack of intrasurgical measurements (such as description of intrabony defects including the number and height of walls of bone, amount of osseous surgical correction and final contours, gingival placement at flap closure) makes it difficult to assess whether the surgical objectives were attained (6, 37, 52, 55).

One important difference in the six studies reviewed is the extent or endpoint to which the osseous resective surgery was performed. A "positive osseous architecture" was produced at the time of surgery in the two studies that reported a sustained difference over 5 years in the reduction of probing depth (43, 86).

At first glance of the studies, it might appear that the greater reduction of probing depth is not a long-term advantage in maintaining the attachment level, since osseous resective surgery and other therapies had similar long-term effects. Most longitudinal clinical trials evaluated the differences between two or more therapeutic approaches by comparing the magnitudes of their mean changes in probing depths and clinical attachment levels over a stated period of time. If the percentage of sites losing attachment is relatively small, differences between therapies may be overshadowed by the data from the more numerous stable sites. In periodontal therapeutic studies, the percentage of sites losing attachment from periodontal disease during a year is quite small, which is a consideration where therapies are compared by mean data. One longitudinal study compared the rate of sites losing ≥3 mm of clinical attachment per year during 7 years of supportive periodontal therapy (Tables 5, 6) (44). Sites treated by osseous resective surgery had a statistically significant lower rate of breakdown than sites treated by root planing or modified Widman surgery. This lower incidence of breakdown may have resulted because osseous resective surgery had produced a greater reduction in probing depth. Even though a root surface associated with a deep pocket is surgically exposed for instrumentation such as with modified Widman surgery, not all plaque and calculus is necessarily removed (11). Apically positioning the gingiva to reduce the pocket, thereby facilitating subsequent instrumentation during supportive periodontal therapy or just positioning the gingiva apically away from an incompletely instrumented diseased root, may also be selectively advantageous as proposed by Waerhaug (88) and Mombelli et al. (58). Other evidence also exists that deeper probing depths may be a risk factor for progression of treated periodontitis (3, 17, 35, 36, 53).

Periodontal therapies have been compared by their effects on clinical inflammatory indices (bleeding on probing, Gingival Index, Periodontal Index and gingival suppuration) in both short and long-term clinical trials. Studies comparing results following osseous resective surgery and nonsurgical therapy reported no differences between therapies (5, 41, 43, 45, 46, 51, 90). Most studies, both short and long term, reported no differences in the inflammatory indices in sites treated by osseous resective surgery and modified Widman surgery or flap access surgery (5, 41, 43, 45, 46, 51, 75, 76, 79, 86, 90).

Concern has been raised that, on longer clinical crowns after osseous resective surgery, it is more difficult for the patient to remove all the supragingival plaque. On the other hand, it has also been proposed that creating interproximal recession and thereby opening the embrasures allows the use of interproximal brushes, which enhances the effectiveness of supragingival plaque control. This also is more likely to occur following osseous resective surgery. All studies that compared the accumulation of supragingival plaque reported no differences between sites treated by osseous resective surgery and modified Widman surgery, flap access surgery or nonsurgical therapy (1, 5, 41, 43, 46, 51, 75, 76, 79, 86, 90, 94).

Summary

Osseous resective surgery necessitates following certain guidelines for proper recontouring of the alveolar bone and proper management and positioning of the gingival tissues. The results from osseous resective surgery are technique sensitive. It has limited use in treating cases with very deep intrabony or hemiseptal defects, which should be treated with a different surgical approach. If osseous resective surgery is used in advanced lesions, a compromise in the amount of probing depth reduction should be expected. Yet, osseous resective surgery provides the surest method of reducing pockets with an intrabony or hemiseptal osseous component of 3 mm or less, albeit at the expense of some attachment in the neighboring less involved sites. Osseous resective surgery has been and remains one of the principal periodontal treatment modalities because of its proven success (Fig. 17).

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