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Aesthetic osseous surgery in the treatment of periodontitis

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Although defect or defect morphology continue to prevail as the basis for treatment in current periodontology, diagnosis must be the basis for periodontal therapy (20). The periodontal therapist should aim at eliminating the causative and contributing factors of the disease. Based on diagnosis, the integration of reparative procedures may lead to definitive treatment, which can help maintain therapeutic results (Fig. 1) (20).

Regeneration of lost periodontal attachment (that is, cementum, periodontal ligament and alveolar bone) remains an important goal of periodontal therapy (5). However, the inductive events, which regulate the differentiation and maturation of the periodontal attachment tissues, are not well understood (30). Considering the complexity of organogenesis in tooth development (32), it may be difficult to perceive that the mere placement of devices such as membranes, allografts and growth factors in a subgingival site is sufficient to induce the formation of original periodontal tissue architecture.

"Regenerative" surgical procedures continue to be performed in hopes of an occasional dramatic result. Most such results are observed in isolated areas of the dentition associated with infrequently significant osseous repair. The nature of periodontal attachment after "regenerative" periodontal surgery is proposed to consist of *de novo* cementogenesis with inserting functional collagen fibers (10). However, "regeneration" of the periodontium may mostly represent a reparative process; that is cemental repair, connective tissue reattachment at those portions of the root not destroyed by periodontal disease or a long junctional epithelium in sites effected by the periodontal lesion (13).

The wide range of probing attachment gain obtained after periodontal therapy is probably due to the complexity of the reparative process of periodontal wound healing (37). Partial versus complete destruction of cementum and the occurrence of specific periodontal pathogens (Fig. 1, 2) may in part explain the variability in the reparative potential of periodontal tissues.

Although case reports of occasional striking results are interesting, modern medicine requires consistency in treatment outcome. The ability to recognize pertinent differences between diseased periodontal sites of similar morphology might enable identification of sites capable of generating clinically significant attachment gains, with or without the adjunctive use of special regenerative aids (Fig. 1, 2) (19). Otherwise, aesthetic osseous surgery is a surgical treatment modality that may be used to effectively eliminate periodontal defects. Aesthetic osseous surgery maintains the coronal aesthetic position of the buccal gingiva, reduces probing depth and stabilizes periodontal attachment. A thorough understanding of the biological principles and proper execution of the surgical technique result in the achievement of superior results.

Preventive medicine

Post-treatment shallow periodontal sites provide reduced risk of future breakdown compared to deep periodontal sites (14). Aesthetic osseous surgery improves access to diseased radicular surfaces for daily oral hygiene by the patient and maintenance by the therapist. Post-treatment mechanical access to causative factors by the patient is consistent with the goal of preventive medicine. Also, the main purpose of regular visits to therapist would be the preservation of the dentition in a state of health, comfort and function, rather than the active treatment of reinfection as a result of residual or recurrent periodontal pockets.

Microbiological evaluation of osseous surgery

The microbiological effectiveness of osseous surgery has been evaluated by Nowzari et al. (18) and Tuan et al. (34). Nowzari et al. (18) reported that peri-


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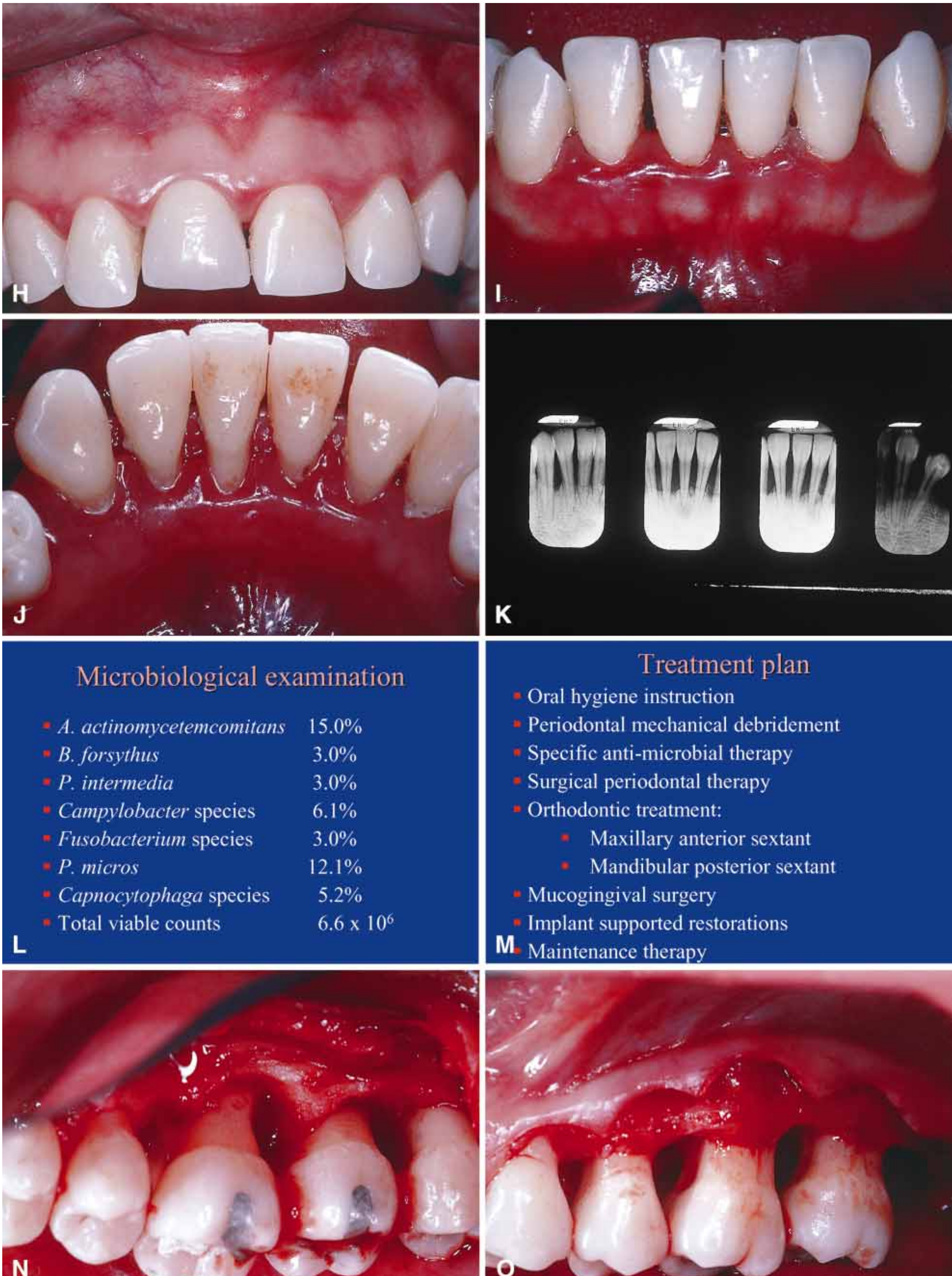
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Microbiological examination
A. actinomycetemcomitans 15.0%
B. forsythus 3.0%
P. intermedia 3.0%
Campylobacter species 6.1%
Fusobacterium species 3.0%
P. micros 12.1%
Capnocytophaga species 5.2%
Total viable counts 6.6 x 10^6
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Treatment plan
Oral hygiene instruction
Periodontal mechanical debridement
Specific anti-microbial therapy
Surgical periodontal therapy
Orthodontic treatment:
Maxillary anterior sextant
Mandibular posterior sextant
Mucogingival surgery
Implant supported restorations
Maintenance therapy
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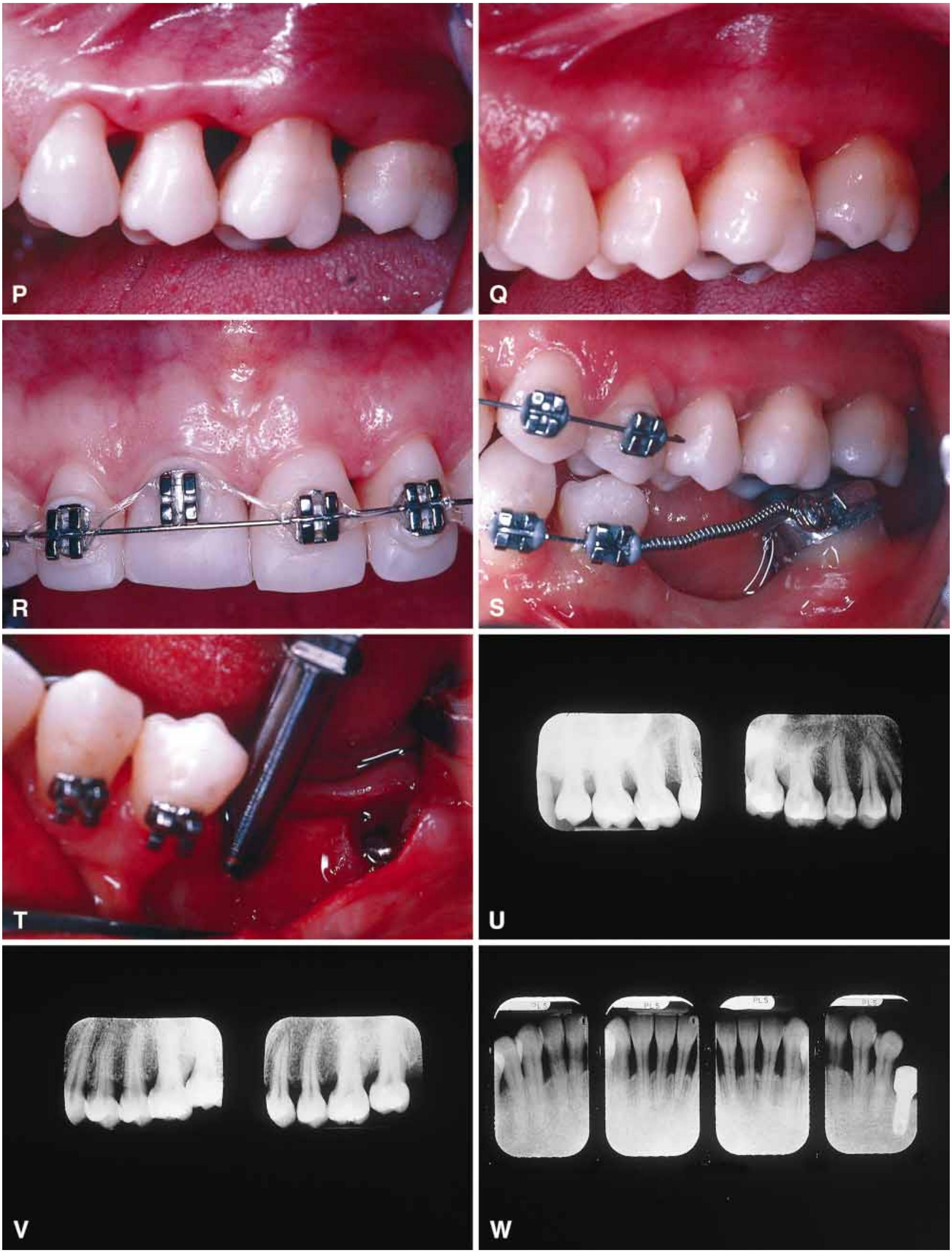
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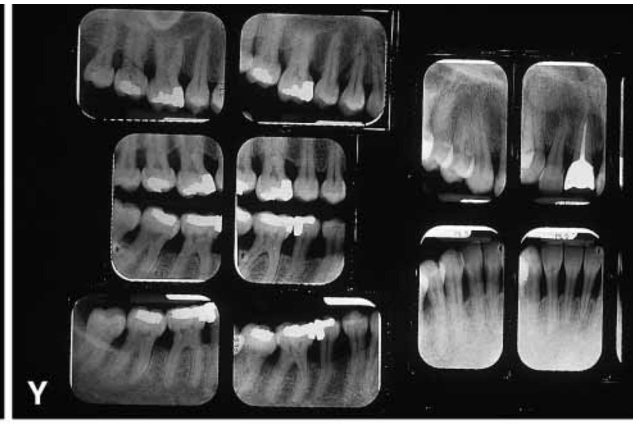


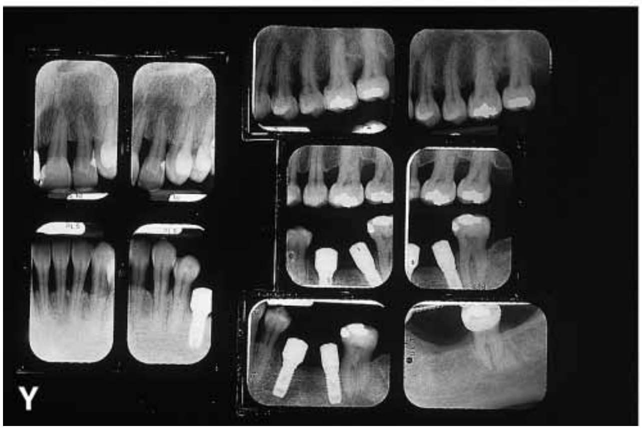
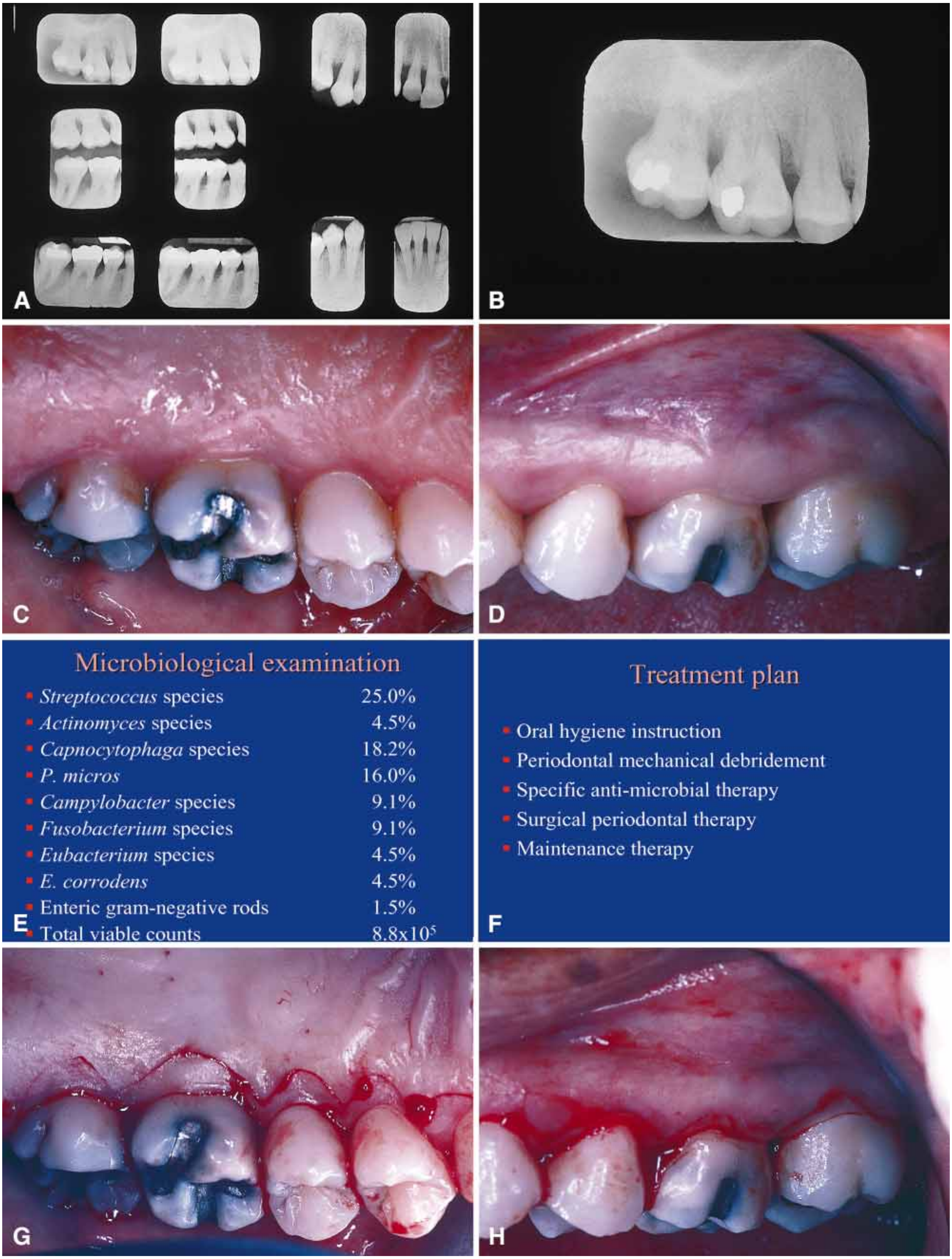


Fig. 1. **A.** Clinical appearance of a 28-year-old woman diagnosed with post-juvenile periodontitis. She was infected by the putative periodontal pathogens *A. actinomycetemcomitans* and *B. forsythus.* **B.** Maxillary occlusal view. **C.** Mandibular occlusal view. **D.** Radiographic examination. Note extensive attachment loss, periapical periodontitis associated with mandibular left central incisor and open contacts. **E.** Maxillary right buccal view. Note inflammation, plaque and heavy calculus. **F.** Maxillary right palatal view. Note inflammation, plaque and heavy calculus. **G.** Maxillary anterior palatal view. Note inflammation and loss of interproximal papillae. **H.** Maxillary anterior buccal view. Note inflammation, egression of lateral incisor and loss of interproximal papillae. **I.** Mandibular anterior buccal view. Note inflammation, plaque and heavy calculus. **J.** Mandibular anterior lingual view. Note inflammation, plaque and heavy calculus. **K.** Radiographic examination of mandibular anterior quadrant. Note extensive bone loss, periapical periodontitis and open contacts. **L.** Microbiological examination. **M.** Treatment plan sequencing. **N.** Maxillary right surgical appearance – palatal view. Note extensive periodontal intraosseous lesions. **O.** Maxillary left surgical appearance – buccal view. Note extensive periodontal intraosseous lesions. **P.** Maxillary left after suture removal – buccal view. **Q.** Maxillary left 7 years after treatment – buccal view. Treatment included periodontal aesthetic surgery. **R.** Maxillary anterior – buccal view. Note reconstruction of interproximal papillae. Treatment included periodontal aesthetic surgery and orthodontic movement of maxillary anterior teeth to eliminate intraosseous lesions. **S.** Maxillary and mandibular left sextants – buccal view. Treatment included periodontal aesthetic surgery and orthodontic movement of mandibular teeth prior to implant placement. **T.** Two implants are inserted to restore absent teeth. **U.** Radiographic examination of maxillary right 7 years after treatment. Note periodontal repair without the use of so-called regenerative devices. This example illustrates the importance of diagnosis in the prognosis of periodontal treatment. **V.** Radiographic examination of maxillary left 7 years after treatment. Note periodontal repair without the use of so-called regenerative devices. **W.** Radiographic examination of mandibular anterior quadrant 7 years after treatment. Note periodontal repair, disappearance of periapical periodontitis and closure of open contacts. **X.** Radiographic examination of mandibular right 7 years after treatment. **Y.** Full-mouth radiographic examination 7 years after treatment. This example illustrates the importance of diagnosis in the prognosis of periodontal treatment and execution of periodontal aesthetic surgery.

odontal sites treated by definitive osseous surgery exhibited no remaining periodontal pocket of ≥5 mm depth at 3 to 12 months post-surgery and virtually no putative periodontal pathogens were detected at the sites treated by osseous surgery (Tables 1, 2). In contrast, multiple deep periodontal pockets of ≥5 mm depth were measured in patients treated only by nonsurgical periodontal debridement, associated with high levels of putative periodontal pathogens, including motile rods, *Actinobacillus actinomycetemcomitans, Prevotella intermedia, Peptostreptococcus micros, Propionibacterium* species, *Porphyromonas gingivalis* and spirochetes (Tables 1, 2).

Tuan et al. (34) reported that, in patients affected by adult periodontitis, apically positioned flap surgery by elimination of interproximal craters was superior to non-osseous flap surgery in reducing ini-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Microbiological examination
Streptococcus species 25.0%
Actinomyces species 4.5%
Capnocytophaga species 18.2%
P. micros 16.0%
Campylobacter species 9.1%
Fusobacterium species 9.1%
Eubacterium species 4.5%
E. corrodens 4.5%
Enteric gram-negative rods 1.5%
Total viable counts 8.8x10^5
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Treatment plan
Oral hygiene instruction
Periodontal mechanical debridement
Specific anti-microbial therapy
Surgical periodontal therapy
Maintenance therapy
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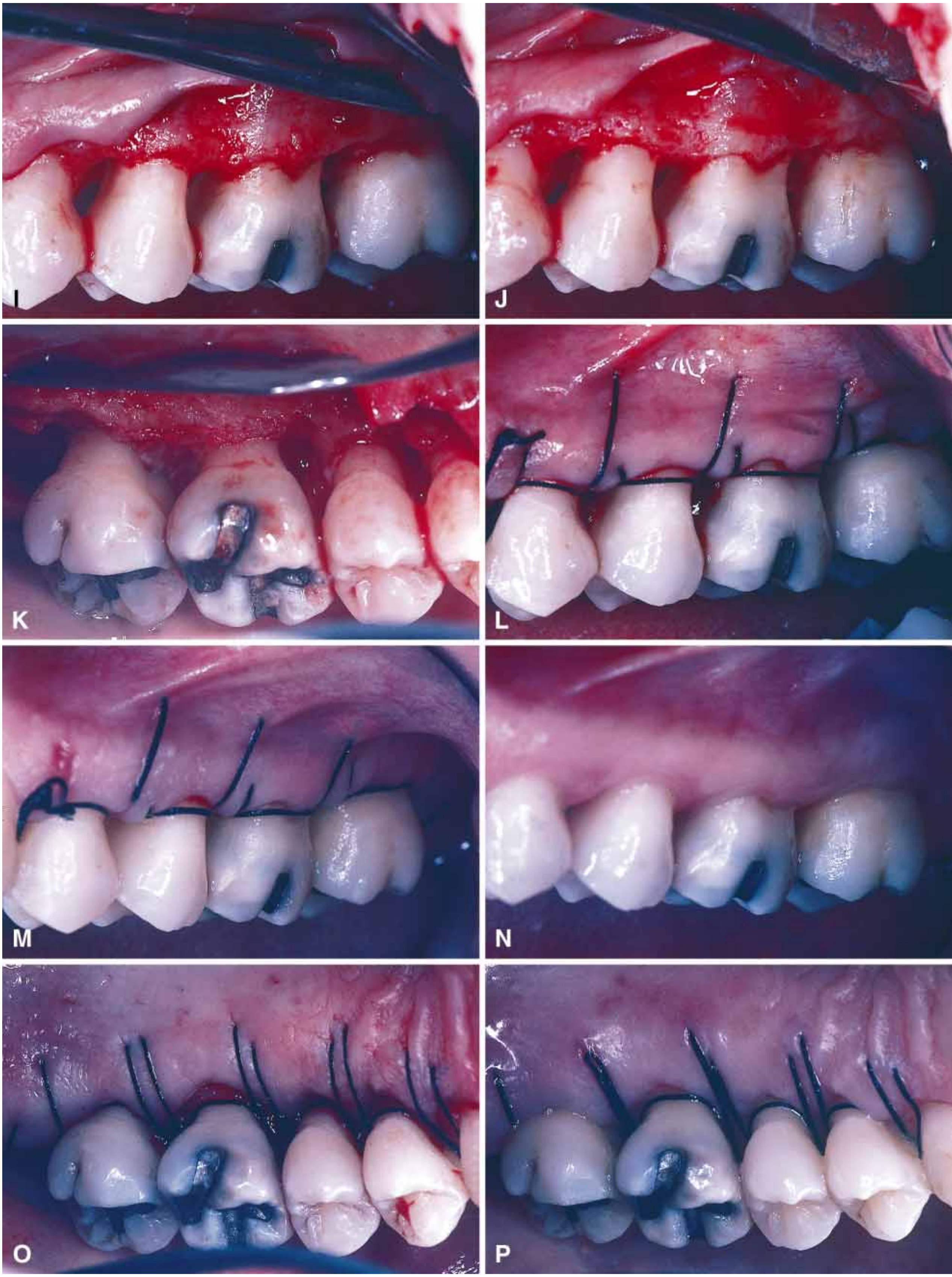
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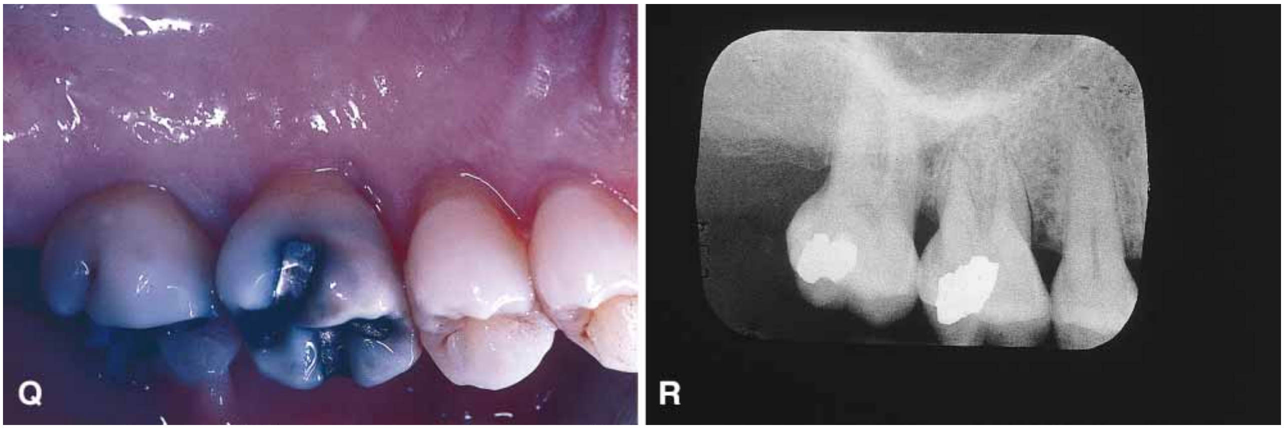


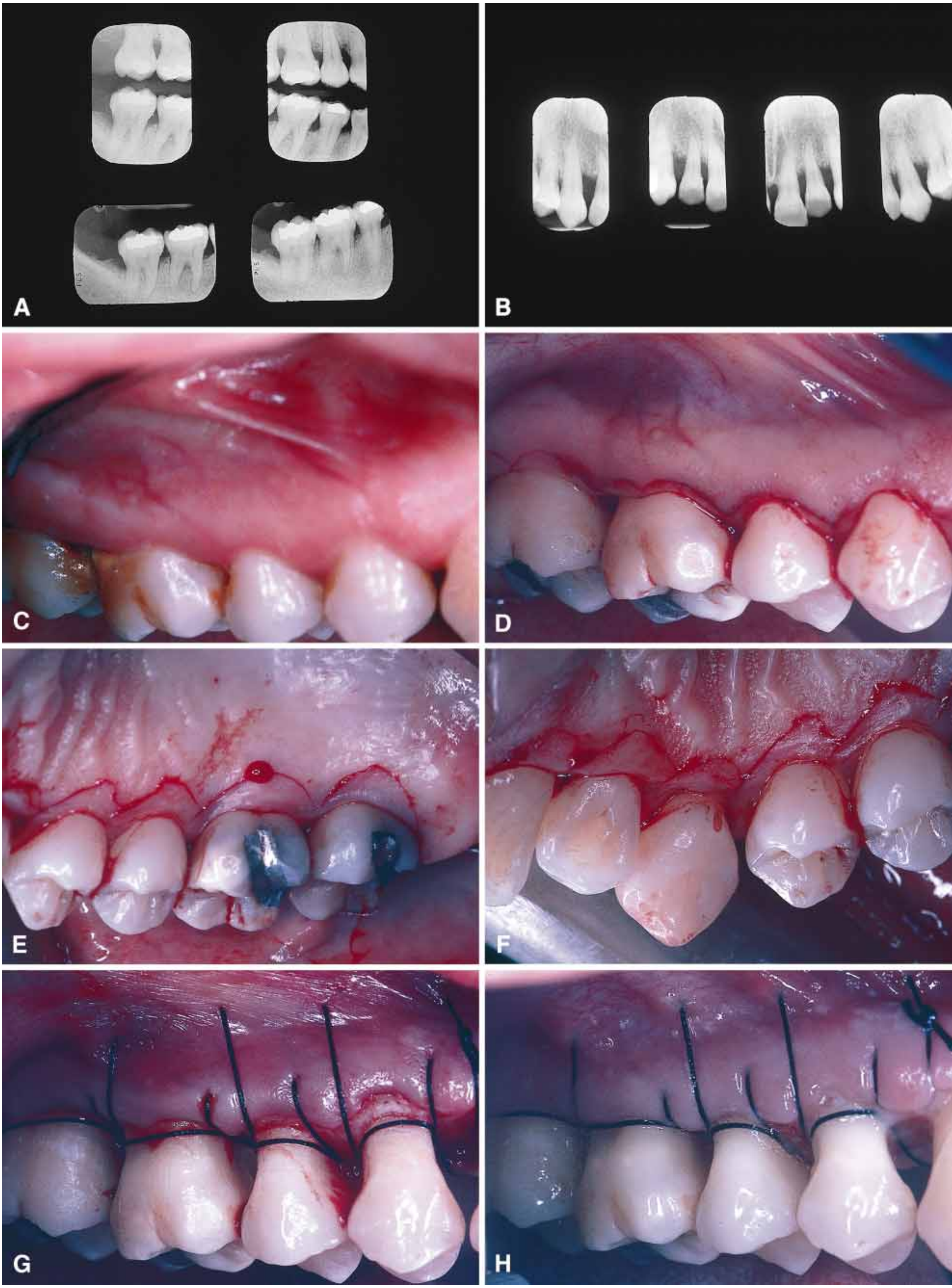
Fig. 2. A. Radiographic examination of a 46-year-old woman diagnosed with advanced adult periodontitis and specific infection. B. Radiographic examination of maxillary left sextant. Enteric gram-negative rods have infected mesial site of the first molar. C. Clinical appearance of maxillary left – palatal view. D. Clinical appearance of maxillary left – buccal view. E. Microbiological examination. F. Treatment plan sequencing. G. Palatal scalloped incision. The incision starts at a distance from the gingival margin and is aimed apically at the osseous tissue. The scalloped incision removes the inflamed tissue and creates a thin flap margin for adaptation to the dentoalveolar unit. Due to the lack of soft tissue flexibility in the palate, a definitive scalloped incision should be performed. The shape of the incision follows the radicular morphology and the depth should be at the level of palatal osseous crest or slightly apical to that after osteoplasty and ostectomy are accomplished. H. Buccal double-scalloped and scalloped incisions start at a distance from the gingival margin and are aimed apically at the osseous tissue to remove the inflamed tissue and create a flap margin for adaptation to the dentoalveolar unit. Double-scalloped incision creates a triangular soft tissue within the healthy gingiva that protects the furcation area of multi-rooted molars during healing. I. Maxillary left surgical view. Note intraosseous periodontal lesion at buccal site of the second molar. J. Osteoplasty eliminated the lesion. Osteoplasty or ostectomy follows double-scalloped morphology to preserve the integrity of the periodontal attachment at the furcation area. K. Maxillary left palatal surgical view. Note extensive periodontal intraosseous lesion at mesial of the first molar. L. After soft tissue plasty, osteoplasty and ostectomy, buccal flap is apically positioned with the use of periosteal continuous suture. M. Clinical appearance 1 week after surgery. Note the absence of supragingival plaque during healing phase. N. Clinical appearance after 2 years – buccal view. O. Palatal flap was apically positioned 0.5 mm to 1 mm apical to the osseous crest. P. Clinical appearance at 1 week. Note the absence of supragingival plaque during the healing phase. Q. Clinical appearance after 2 years – palatal view. R. Radiographic examination after 2 years. Note periodontal repair at the mesial site of the first molar and the elimination of intraosseous defect without the use of a so-called regenerative device. This example illustrates the importance of diagnosis in the prognosis of the periodontal treatment and the appropriate integration of hard and soft tissue reparative procedures.

tial periodontal pocket depths and maintaining shallow probing depths. Post-treatment, *A. actinomycetemcomitans* and *P. gingivalis* were not detected in patients treated by osseous surgery. In contrast, *A. actinomycetemcomitans*, *P. gingivalis* and *Bacteroides forsythus* were recovered in many post-treatment periodontal samples of patients treated by non-osseous surgery.

Nowzari et al. (18) and Tuan et al. (34) found that osseous surgery yielded better suppression of *P. intermedia*, *Fusobacterium* species, *P. micros* and *Campylobacter rectus*. In fact, nonsurgical mechanical debridement and non-osseous surgery had virtually no effect on the recovery of subgingival *Fusobacterium* species, *P. micros* and *C. rectus*.

In 1985, Olsen et al. (33) reported that periodontal pocket depths remained significantly reduced for at least 5 years after osseous surgery. Periodontal pocket depths of sites treated with flap curettage surgery returned to pre-treatment levels before the end of 5 years. Osseous surgery resulted in significantly more reduction of bleeding upon probing than non-osseous surgery. Olsen et al. (33) and Nowzari et al. (18) found significant reductions of gingival bleeding following osseous surgery. Since repeated gingival bleeding is a major indicator of risk for future periodontal breakdown (14), osseous surgery gives rise to a post-surgical environment that is more supportive of stable periodontal conditions.

The microbiological findings provide an explanation for the differing clinical outcome following osseous and non-osseous surgery or nonsurgical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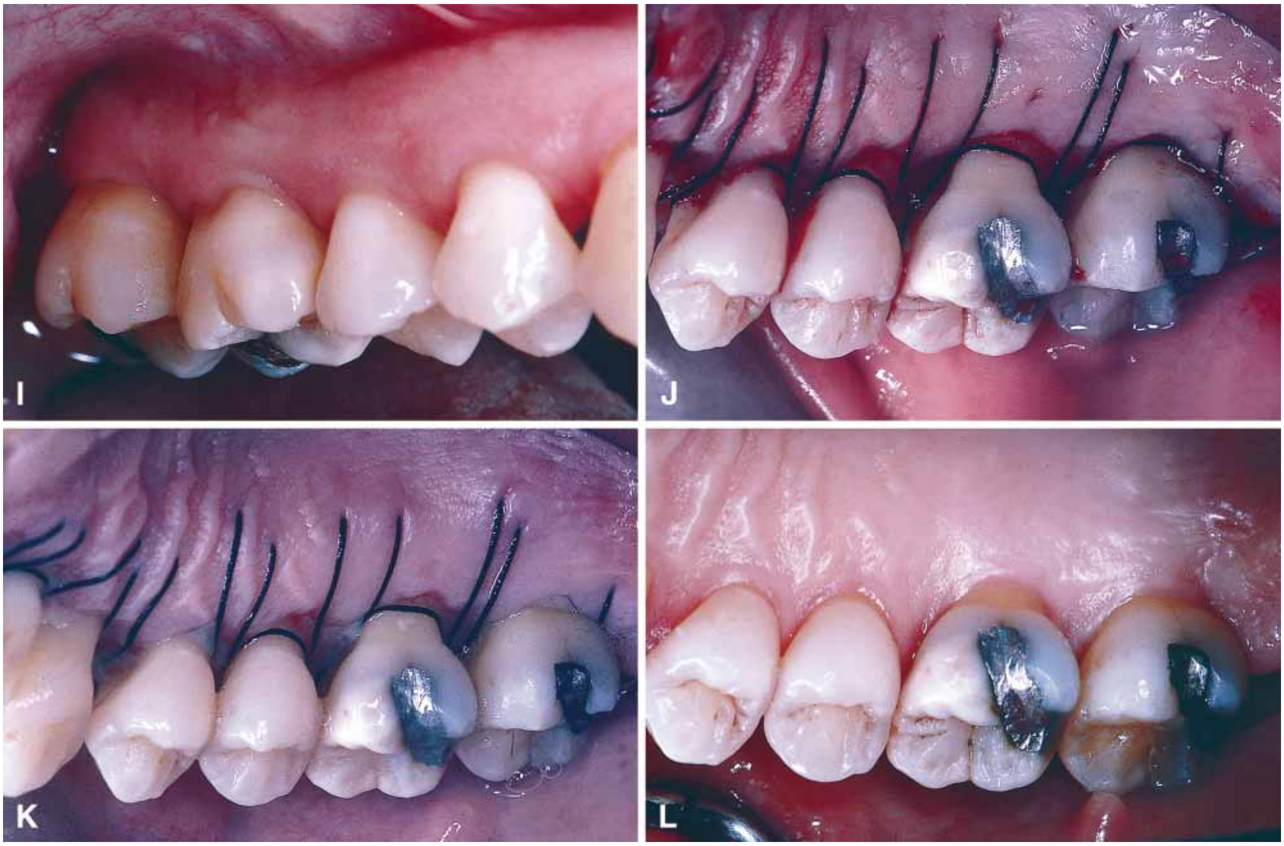


Fig. 3. A. Radiographic examination of a 46-year-old woman diagnosed with advanced adult periodontitis. B. Radiographic examination of the maxillary anterior quadrant. Note extensive radiographic bone loss. C. Clinical appearance. Note supragingival plaque and heavy calculus. D. Buccal double-scalloped and scalloped incisions start at a distance from the gingival margin and is aimed apically at the osseous tissue to remove the inflamed tissue and create a flap margin for adaptation to the dentoalveolar unit. Double scalloped incision creates a triangular soft tissue within the healthy gingiva that protects the furcation area of multi-rooted molars during healing. E. Palatal scalloped incision. The incision starts at a distance from the gingival margin and is aimed apically at the osseous tissue. Due to the lack of soft tissue flexibility in the palate, a definitive scalloped incision should be performed. The shape of the incision follows the radicular morphology and the depth should be at the level of palatal osseous crest or slightly apical to that after osteoplasty and ostectomy are accomplished. F. Palatal scalloped incision. The scalloped incision removes the inflamed tissue and creates a thin flap margin for adaptation to the dentoalveolar unit. G. After soft tissue plasty, osteoplasty and ostectomy, buccal flap is apically positioned with the use of periosteal continuous suture to enhance the depth of the vestibule, move apically the muscle insertions and increase the zone of keratinized tissue. H. Clinical appearance 1 week after surgery. Note the absence of supragingival plaque during healing phase. I. Clinical appearance after 2 years – buccal view. Note the aesthetic appearance, increase in the vestibular depth, apical positioning of the muscle insertion and enhanced zone of keratinized tissue. J. Palatal flap was apically positioned 0.5 mm to 1 mm apical to the osseous crest. K. Clinical appearance at 1 week. Note the absence of supragingival plaque during the healing phase. L. Clinical appearance after 2 years – palatal view. Aesthetic osseous surgery provides postsurgical shallow probing depths by creating an osseous architecture similar to gingival morphology where osteoplasty and ostectomy places the lingual osseous crest in an apical position that corresponds to the deepest part of the osseous defect. The buccal osseous crest maintains a coronal aesthetic position.

mechanical debridement. The failure to effectively control periodontal pathogens might account for the negligible decline in the number of gingival bleeding sites in patients treated by non-osseous surgery or nonsurgical mechanical debridement, whereas the improved microbiological status with osseous surgery may be related to shallow probing depths resulting from osteoplasty and ostectomy. The microbiota of shallow periodontal sites is very similar to that of supragingival plaque (14). Also, more effective subgingival cleaning by brushing and flossing can change the pocket microbiota from one containing high proportions of gram-negative anaerobes to one predominated by streptococci and other gram-positive species with little or no periodontopathic potential (14).

Table 1. Demographics and clinical parameters of patients treated by osseous surgery in comparison to patients treated by nonsurgical periodontal debridement

Treatment group	*n*	Sex	Age in years mean (range) SD	No. of teeth mean (range) SD	Mean no. of sites with probing depth ≥5 mm (range) SD	Mean no. of sites with bleeding on probing (range) SD	Mean plaque index (range) SD
Osseous surgery	20	11 F	38.5 (29–50) 5.9	26.9 (18–31) 3.0	0	1.9 (0–4) 1.4	0.32 (0.07–0.6) 0.1
Nonsurgical periodontal debridement	22	5 F	53.7 (29–69) 8.8	23.7 (18–30) 3.8	23.0 (8–44) 8.9	15.5 (7–26) 6.5	0.52 (0.17–0.92) 0.2

Source: Nowzari et al. (18).

Table 2. Subgingival microbiota of patients treated by osseous surgery or by nonsurgical periodontal debridement at 3 to 12 months post-treatment[a]

Organisms[b]	Patients treated by osseous surgery (*n*=20)	Patients treated by nonsurgical periodontal debridement (*n*=22)
	No. positive, mean %	No. positive, mean %
A. actinomycetemcomitans	0	5, 0.7
P. gingivalis	0	9, 12.3
P. intermedia	0	19, 9.6
B. forsythus	0	11, 2.8
C. rectus	0	16, 3.9
Capnocytophaga species	0	7, 4.0
Fusobacterium species	1, 0.1	21, 6.3
P. micros	0	19, 10.3
Propionibacterium species	0	0
Beta-hemolytic streptococci	0	3, 0.9
enteric gram-negative rods	0	1, 0.5
M. dentalis	0	0
Motile rods	1, 0.4	15, 11.2
Yeasts	0	1, <0.01
Spirochetes	0	6, 1.3
P. gingivalis DNA probe positive	2, 10.0[c]	15, 68.2
B. forsythus DNA probe positive	2, 10.0[c]	14, 63.6

[a] 0% of a bacterial species denotes that the organism comprises less than 0.01% of the cultivable microflora. *A. actinomycetemcomitans* and yeasts grown on selective medium are listed with lower percentage of occurrence.
[b] Samples are pooled.
[c] No., % positive.
Source: Nowzari et al. (18).

Principles of aesthetic osseous surgery

The principles of modern aesthetic osseous surgery are based on therapeutic methods described by Widman in 1918 (36), Black in 1924 (3), Carranza in 1935 (4), Schluger in 1949 (29), Friedman in 1955 (7), Ochsenbein & Bohannan in 1963 (23), and Ochsenbein in 1986 (24).

Flap designs and incisions in aesthetic osseous surgery

Periodontal flaps are full thickness (mucoperiosteal) (Fig. 4–8) or a combination of full and partial thickness (mucosal) (Fig. 2, 3). In both situations, soft tissue is reflected to expose the underlying osseous structures for recontouring. Surgical flap design may

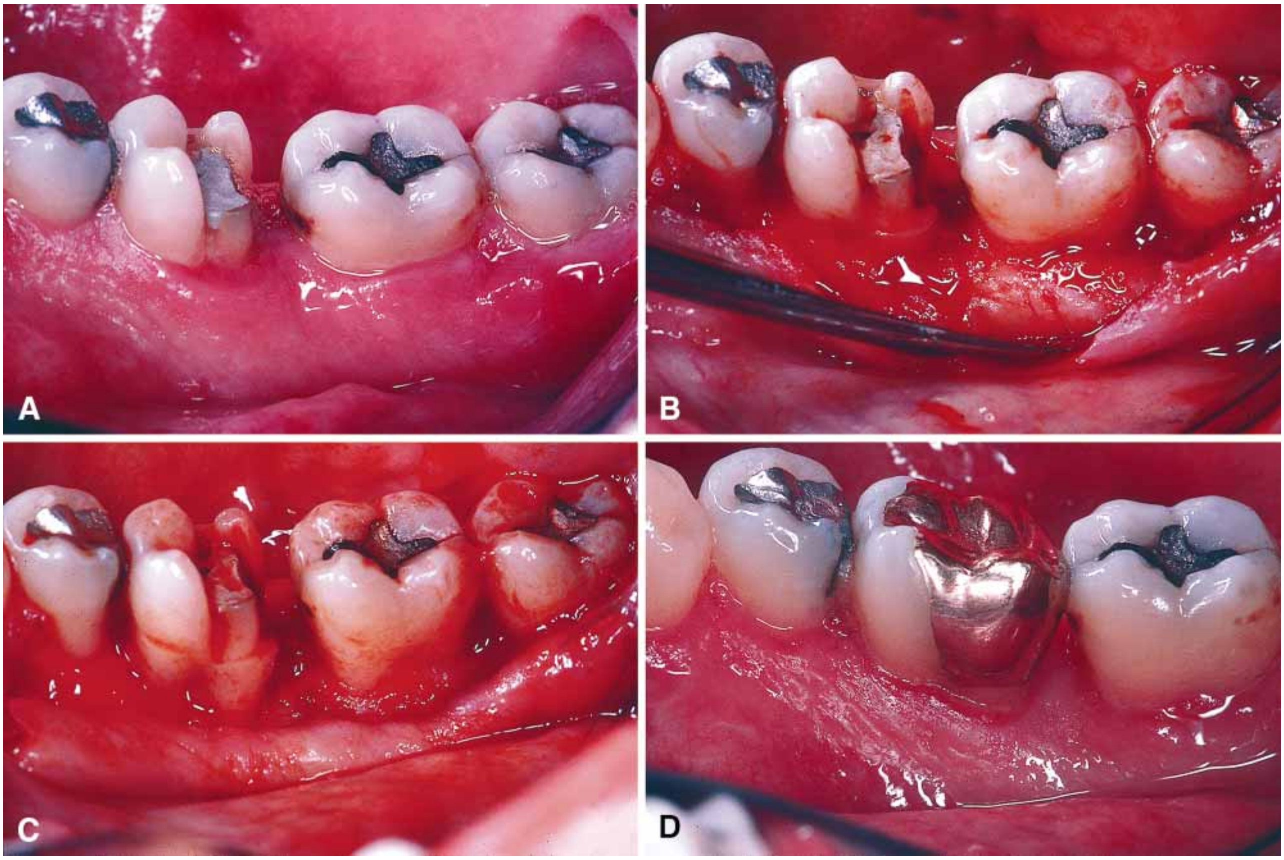


Fig. 4. A. Clinical appearance of mandibular right sextant in a 45-year-old male smoker. Probing depths of 6 mm distal of the first molar and mesial of the second molar are measured. B. Surgical appearance. Note the 3-mm-deep interproximal crater between the first and second molars. C. Osteoplasty and 2- to 4-mm double-scalloped lingual ostectomy have provided a 15° declining buccolingual slope to provide buccolingual transition space for gingival adaptation. A well-declined buccolingual interproximal slope prevents interdental gingival proliferation and bridging that ultimately lead to pocket reformation. D. Clinical appearance after 3 years. Double-scalloped incision and double-scalloped ostectomy created triangular soft tissue that protects the furcation area. Double-scalloped ostectomy preserved the integrity of the periodontal attachment at the furcation area.

apically preserve the buccal periosteum (partial thickness) when the flap is to be positioned apically (Fig. 2, 3). The periosteal suturing stabilizes the flap in an apical position.

The outer portion of the periodontal pocket wall is transformed into attached gingiva. Removal of pocket epithelium by a scalloped internal bevel incision promotes healing, with a tight adherence of healthy connective tissue to the dentoalveolar unit, and can increase the width of attached gingiva.

It should be emphasized that intracrevicular and crestal incisions are not consistently effective in the removal of diseased crevicular epithelium (6, 15). Scalloped incisions performed in aesthetic osseous surgery preserve a healthy interdental soft tissue by placing the interproximal incisions in an apical position and effectively eliminate the papillary epithelium.

Palatal scalloped incision

First, a palatal scalloped incision is made. The incision starts at a distance from the gingival margin and is aimed apically at the osseous tissue. The scalloped incision removes the inflamed tissue and creates a thin flap margin for adaptation to the dentoalveolar unit following osteoplasty and ostectomy. The coronal portion of the incision contains the epithelium of the pocket and granulomatous tissue and will be discarded (Fig. 9). The palatal scalloped incision provides the interproximal soft tissue for primary flap adaptation.

Due to the lack of soft tissue flexibility in the palate, a definitive scalloped incision should be performed (Fig. 8, 9). A sulcular incision or an incision made at the gingival margin result in the residual presence of a pocket by preserving the granulo-

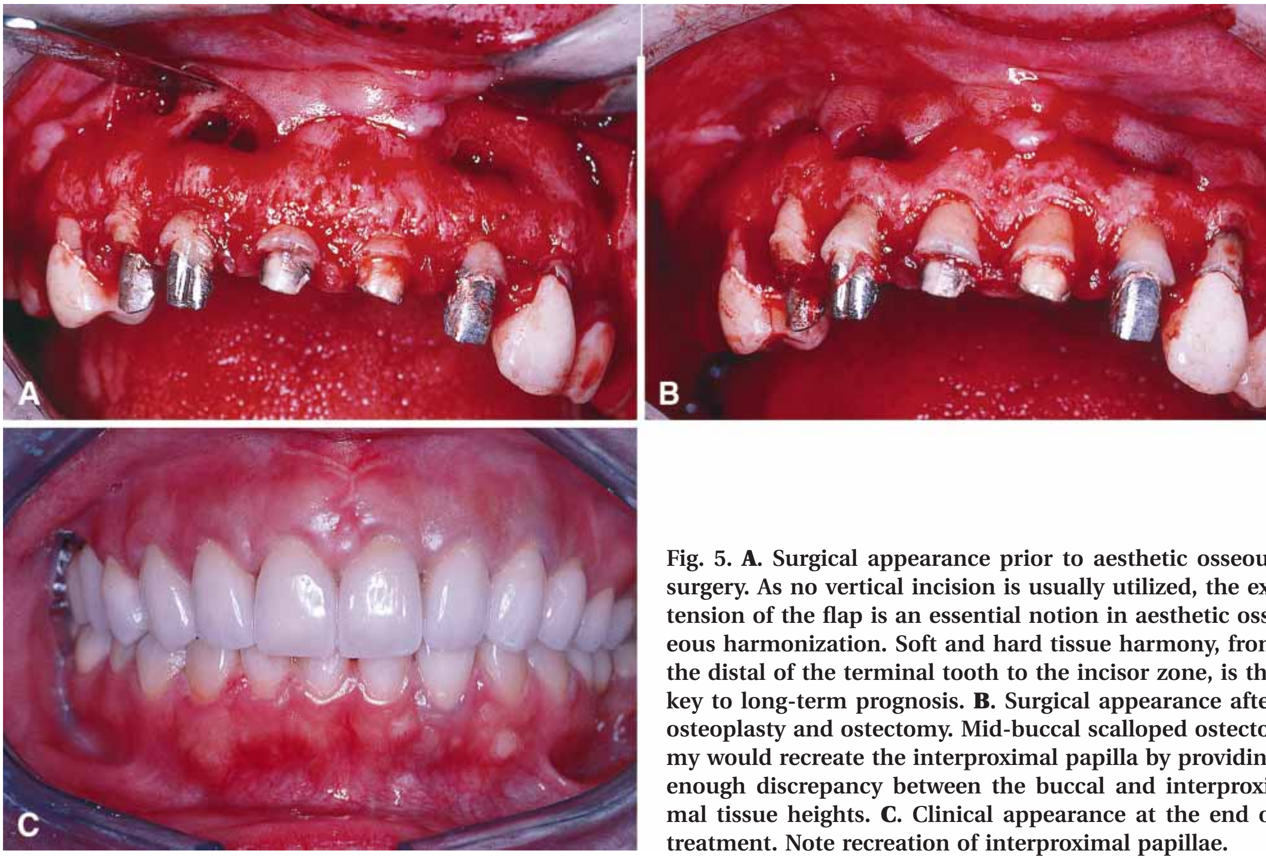


Fig. 5. A. Surgical appearance prior to aesthetic osseous surgery. As no vertical incision is usually utilized, the extension of the flap is an essential notion in aesthetic osseous harmonization. Soft and hard tissue harmony, from the distal of the terminal tooth to the incisor zone, is the key to long-term prognosis. B. Surgical appearance after osteoplasty and ostectomy. Mid-buccal scalloped ostectomy would recreate the interproximal papilla by providing enough discrepancy between the buccal and interproximal tissue heights. C. Clinical appearance at the end of treatment. Note recreation of interproximal papillae.

matous tissue and extending the flap coronal to the dentoalveolar junction. The shape of the incision follows the radicular morphology and the depth should be at the level of or slightly apical to the palatal osseous crest after osteoplasty and ostectomy are accomplished.

Once the palatal flap is reflected, direct clinical examination of the osseous morphology provides additional diagnostic information to finalize the design of the buccal gingival flap.

Lingual incision

Lingual double-scalloped and scalloped incisions start at a distance from the gingival margin and are aimed apically at the osseous tissue to remove the inflamed tissue and create a flap margin for adaptation to the dentoalveolar unit. The double-scalloped incision creates a triangular soft tissue within the healthy gingiva that protects the furcation area of multi-rooted molars during healing. Ostectomy follows double scalloped morphology as well, to preserve and improve the integrity of the periodontal attachment at the furcation area. The coronal granulomatous tissue portion of the incision is discarded.

A major limiting factor for lingual incision is the width of keratinized tissue available at the time of surgery. A limited zone of keratinized tissue prohibits a definitive scalloped incision. Consequently, the scalloped incision may have to be made at a more coronal position. Preservation of 2 to 3 mm of keratinized tissue may be used as a general guideline.

Buccal incision

Buccal double-scalloped and scalloped incisions start at a distance from the gingival margin and are aimed apically at the osseous tissue to remove the inflamed tissue and create a flap margin for adaptation to the dentoalveolar unit. As described above, the double-scalloped incision creates a triangular soft tissue within the healthy gingiva that protects the furcation area of multi-rooted molars during healing. Ostectomy follows double-scalloped morphology as well, to preserve the integrity of the periodontal attachment at the furcation area. The coronal granulomatous tissue portion of the incision is discarded. The scalloped incision restores the health and the aesthetic aspect of the periodontium by removing the granulomatous tissue and increasing the width of attached gingiva as healing progresses.

A major limiting factor for buccal incision is the width of keratinized tissue available at the time of surgery. A limited zone of keratinized tissue prohibits a definitive scalloped incision. Consequently, the scalloped incision may have to be made at a more coronal position. Preservation of 2 to 3 mm of keratinized tissue may be used as a general guideline. However, the periodontal surgeon incises the buccal gingival flap in such a way as to compensate for the removal of osseous tissue and to benefit from the healing originating from the periodontal ligament and endosteum for increasing the soft tissue height (21).

Distal extension

As no vertical incision is usually utilized, the distal extension of the flap, well beyond the mucogingival junction distal to the tuberosity or retromolar pad, is a prerequisite for flap flexibility and access to osseous tissues (Fig. 8). Distal incisions start within the attached gingiva and follow the underlying osseous tissue beyond the mucogingival line. A distal extension confined to attached gingiva prohibits flap flexibility, access and visibility and may jeopardize the blood supply due to trauma of the flap. Distal extension beyond the mucogingival junction is an essential notion in aesthetic osseous surgery.

When a vertical incision is used to reduce the mesial extension of the buccal flap, the lingual or palatal flaps are extended more mesially than the vertical buccal incision. The vertical incision is not placed in the center of an interdental papilla or over the mid-radicular surface. Rather, the incision is made at the line angles of a tooth to include the papilla in the gingival flap.

The vertical incision is composed of a horizontal component at the coronal part, an internally curved component at the mid-part and a cut-back component at the apical part within the mucosa.

The horizontal component improves tissue adaptation at closure. Internally curved and cut-back components provide flap flexibility and reduce the tension by increasing the length of the incision.

Mesial extension

Lingual or palatal flaps can be extended to the incisor area and buccal flaps to the premolar–canine area. The mesial extension of the lingual and palatal flaps along with the distal extension of the buccal and lingual and palatal flaps permit access for osseous harmonization of the entire quadrant. The periodontal surgeon should not limit the periodontal flap to a small number of teeth. Soft and hard tissue harmony over the entire quadrant, from the distal of the terminal tooth to the incisor zone, is the key to a good long-term prognosis.

The thickness of gingival flap must be measured before the flap is reflected to the final position. The periodontal surgeon will have more control to thin the flap prior to the complete reflection. A mobile flap is difficult to trim. Well-executed flaps are essential to prevent pocket recurrence and reinfection.

Maxillary anterior teeth

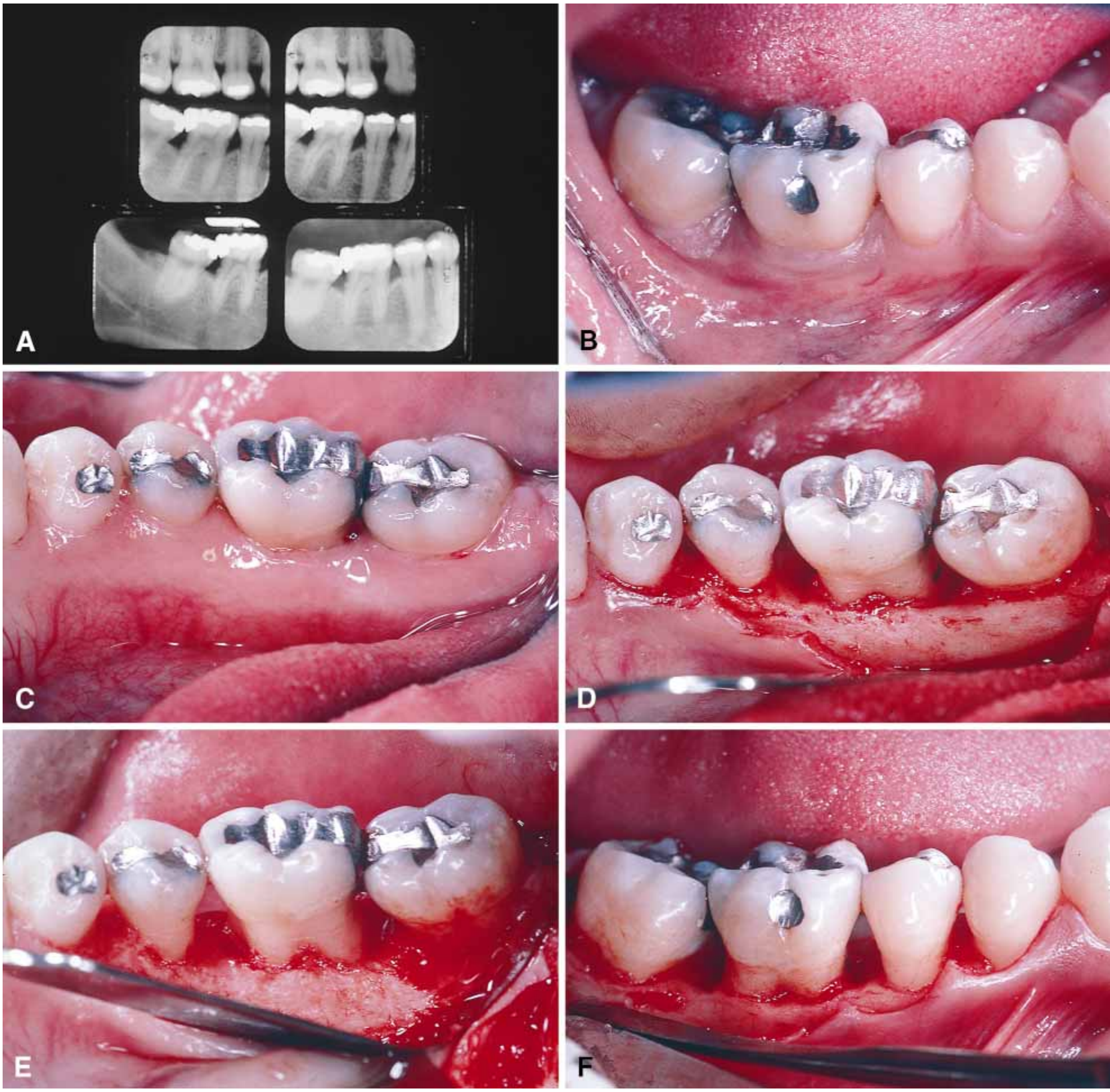
For maxillary anterior teeth no buccal flap or a flap not reflected beyond the mucogingival junction may be utilized. However, in the palate, a definitive, horizontal, scalloped incision should be performed. The shape of the incision follows the radicular morphology and the depth should be at the level of the palatal osseous crest or slightly apical to that after osteoplasty and ostectomy are accomplished. The palatal flap usually provides enough access for not only palatal but also interproximal osseous recontouring.

The palatal sulcular incision or an incision made at the gingival margin would not improve the aesthetics of the buccal soft tissue. On the contrary, the pocket re-formation by preserving the granulomatous tissue and pocket epithelium and extending the flap coronal to the dentoalveolar junction would prohibit a buccopalatally inclined interproximal slope. Over its entire length, the interdental height of the osseous tissue should be coronal to the palatal radicular bone.

Osteoplasty and ostectomy in esthetic osseous surgery

Rationale and technique

Although flap surgery provides access to radicular structures (27), it does not provide optimal soft tissue plasty, osteoplasty-ostectomy (7) and tissue adaptation. After flap surgery, unlike the contours of the alveolar osseous crest, the form of the gingival tissue follows the scalloped pattern of the cemento-enamel junction. Consequently, discrepancies between gingival tissue and the underlying alveolar architecture leads to the recurrence of periodontal pockets and possibly reinfection (7, 16, 23, 24).



Aesthetic osseous surgery provides postsurgical shallow probing depths by creating an osseous architecture that mimics that of gingival morphology, whereas osteoplasty and ostectomy places the lingual osseous crest in an apical position that corresponds to the deepest part of the osseous defect (Fig. 4, 6, 8, 9). Preservation of the buccal osseous crest ensures a coronal aesthetic position. Interproximal alveolar bone assumes a 10° to 15° declining buccolingual slope to provide buccolingual transition space for gingival adaptation. A well-declined buccolingual interproximal slope prevents interdental gingival proliferation and bridging with the risk of pocket reformation (7, 16, 23, 24).

Supporting alveolar bone sacrificed per tooth after osseous surgery averages only 0.6 mm (31). Also, ostectomy is mainly performed on midlingual or midpalatal radicular surfaces and averages only 1 mm (31). The integrity of buccal and interproximal attachment is preserved or improved (Fig. 6, 8).

Indications and contraindications

Aesthetic osseous surgery can be accomplished where periodontitis is associated with interdental osseous craters, intraosseous defects, irregular horizontal attachment loss and moderate furcation involvement. Osseous craters are the most common

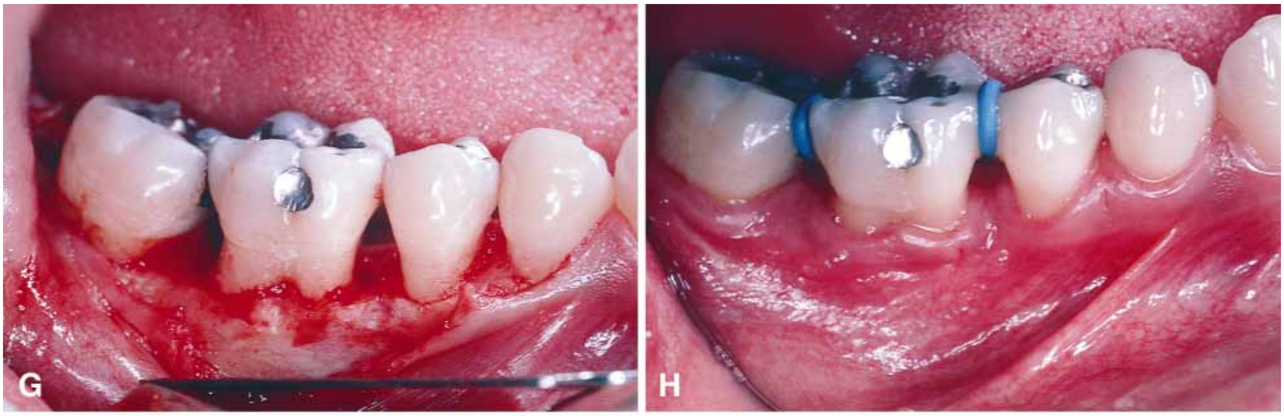


Fig. 6. A. Radiographic examination of a 32-year-old woman diagnosed with adult periodontitis. Note the intraosseous defect and heavy calculus associated with the first mandibular molar. B. Clinical appearance – buccal view. C. Clinical appearance – lingual view. Mesial and distal of first molar present 6-mm periodontal probing depth. D. Surgical appearance – lingual view. Note the 2- to 3-mm-deep osseous lesion distal and mesial of the first molar. E. Osteoplasty/ostectomy places the lingual osseous crest in an apical position that corresponds to the deepest part of the osseous defect. A 15° declining buccolingual slope provides buccolingual transition space for gingival adaptation. F. Surgical appearance – buccal view. G. Double-scalloped ostectomy preserves the integrity of the periodontal attachment at the furcation area. H. Clinical appearance – buccal view. Osseous surgery provides postsurgical shallow probing depths of 0.5 to 1 mm by creating an osseous architecture similar to gingival morphology. I. Clinical appearance – lingual view. A well-declined buccolingual interproximal slope prevents interdental gingival proliferation and bridging that ultimately lead to pocket reformation.

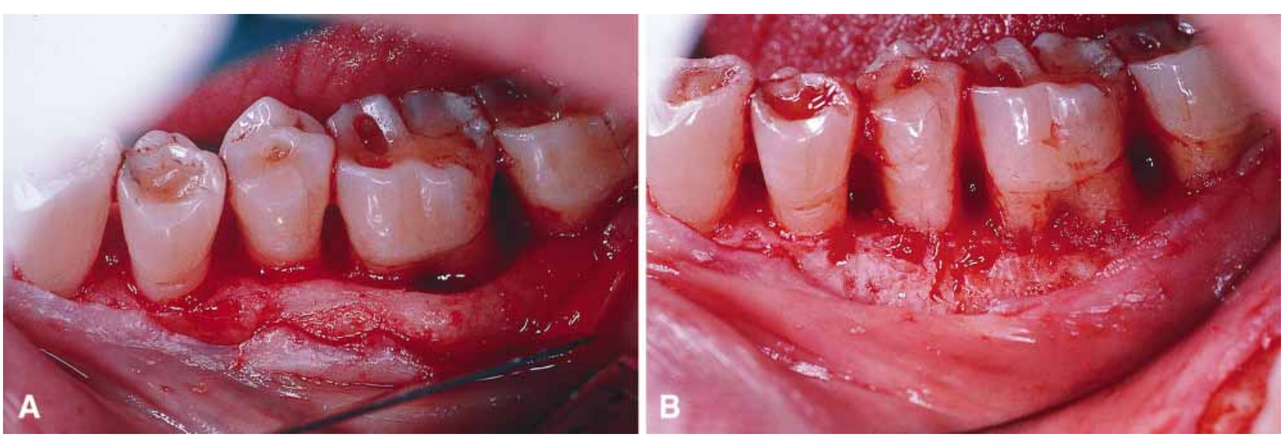


Fig. 7. A. Surgical appearance of a mandibular first molar in a 55-year-old man. Periodontitis is characterized by a deep intraosseous furcation defect and irregular attachment loss. B. Osseous surgery provides an osseous architecture similar to gingival morphology.

type of periodontal defects and constitute about one third of all osseous defects (Fig. 8, 9) and two thirds of all mandibular osseous defects (16, 17). The high frequency of osseous craters emphasizes the importance of knowledge on technical aspects of aesthetic osseous surgery in periodontal therapy.

The type of crater and the relationship of the base of the crater to the root trunk dictate the type and

Fig. 8. A. Clinical appearance of maxillary right in a 52-year-old man diagnosed with adult periodontitis – palatal view. B. Interproximal osseous crater characterized periodontitis. C. Aesthetic osseous surgery eliminated the palatal wall of the osseous defect and palatal ostectomy ensured apical positioning of the radicular osseous crest

degree of osteoplasty and ostectomy. Craters are classified as shallow (1 to 2 mm), medium (3 to 4 mm) and deep (5 mm and more) (24). Root trunks are classified as short (3 mm), average (4 mm) and long (5 mm or more) in the maxilla and short (2 mm), average (3 mm), and long (4 mm or more) in the mandible (24).

The following mean root trunk lengths have been measured for **maxillary** molars in a Caucasian population (12). First molars: 4.1 mm on the buccal, 4.7 mm on the mesial and 4.7 mm on the distal aspect. Second molars: 4.3 mm on the buccal, 6.4 mm on the mesial and 4.8 mm on the distal aspect. First molars present 90% medium or long buccal root trunk, 91% medium or long mesial root trunk and 83% medium or long distal root trunk. Second molars present 82% medium or long buccal root trunk, 84% medium or long mesial root trunk and 84% medium or long distal root trunk. First molars with short buccal root trunks represent only 10% (12).

The following mean root trunk lengths have been measured for **mandibular** molars in a Caucasian population (12). First molars: 3.3 mm on the buccal and 4.3 mm on the lingual aspect. Second molars: 3.3 mm on the buccal and 3.8 on the lingual aspect. First molars present 84% medium or long buccal root trunk and 87% medium or long lingual root trunk. Second molars present 92% medium or long buccal root trunk and 92% medium or long lingual root trunk (12).

in relation to the interdental bone. Interproximal alveolar bone assumed a 15° declining buccopalatal slope to provide buccolingual transition space for gingival adaptation. The well-declined buccolingual interproximal slope prevents interdental gingival proliferation and bridging, which ultimately lead to pocket reformation. D. Clinical appearance after 9 years – palatal view. Osseous surgery provided postsurgical shallow probing depths of 0.5 to 1 mm by creating an osseous architecture similar to gingival morphology. E. Clinical appearance of maxillary right – buccal view. F. Periodontitis was characterized by intraosseous lesion buccal and distal of second molar. Note negative osseous architecture between first molar and second premolar. G. After aesthetic osseous surgery, the buccal osseous crest maintains a coronal position. Osteoplasty eliminated the second molar intraosseous lesion. Buccal double-scalloped ostectomy on the molars and minor ostectomy on premolar provided positive architecture. H. Clinical appearance after 9 years – buccal view. Osseous surgery provided postsurgical shallow probing depths of 1 mm to 2 mm by creating an osseous architecture similar to gingival morphology.

Because of the high percentage of maxillary and mandibular molars presenting medium and long root trunks and the high incidence of shallow and medium osseous craters (12, 16, 17, 24), the majority of periodontal defects can be eliminated by aesthetic osseous surgery (Fig. 6). Osteoplasty eliminates the lingual and palatal wall of the osseous defect and lingual and palatal ostectomy ensures an apical positioning of the radicular osseous crest in relation to the interdental bone. After ostectomy, longer root trunks provide sufficient remaining periodontal attachment coronal to furcations.

Medium craters require a more pronounced interproximal buccolingual and palatal slope and radicular ostectomy. It should be emphasized that in maxillary molars the mid-palatal root presents no furcation and that the lingual root trunks' length of the first and second mandibular molars are on average 1 mm and 0.5 mm longer, respectively, than the buccal root trunk.

Minor buccal double-scalloped ostectomy on the molars and single-scalloped ostectomy on premolars provide positive bony architecture and can eliminate the need for excessive lingual or palatal ostectomy. Mid-buccal scalloped or double-scalloped ostectomy would give the illusion of interproximal papilla by creating enough discrepancy between the buccal and interproximal tissue heights (Fig. 5).

Elimination of shallow intraosseous defects, irregular horizontal attachment loss and moderate furcation involvement follow the same principles (Fig. 7). However, orthodontic periodontal movement best treats intraosseous defects (11, 27). To eliminate or reduce inflammation, periodontal surgery may precede the orthodontic movement. After the completion of orthodontic movement, aesthetic osseous surgery may still be indicated to finalize the treatment.

By stretching the gingival fiber apparatus during eruptive movement, tension is imparted to the entire osseous housing of the tooth, stimulating osseous apposition at the alveolar crest (2) and elimination of the intraosseous defect (35). The eruptive movement also increases the zone of attached gingiva (2, 35), as the mucogingival junction remains stable when the gingival margin migrates coronally (1).

It should be noted that a great healing potential of periodontal intra-osseous lesions has been reported by Prichard (25, 26), Goldman (8) Goldman & Cohen (9). Rosling et al. (28) also found a mean gain of 3.5 mm probing attachment and 80% bone fill in sites maintained on high levels of oral hygiene after periodontal surgery. Rosling et al. (28) observed

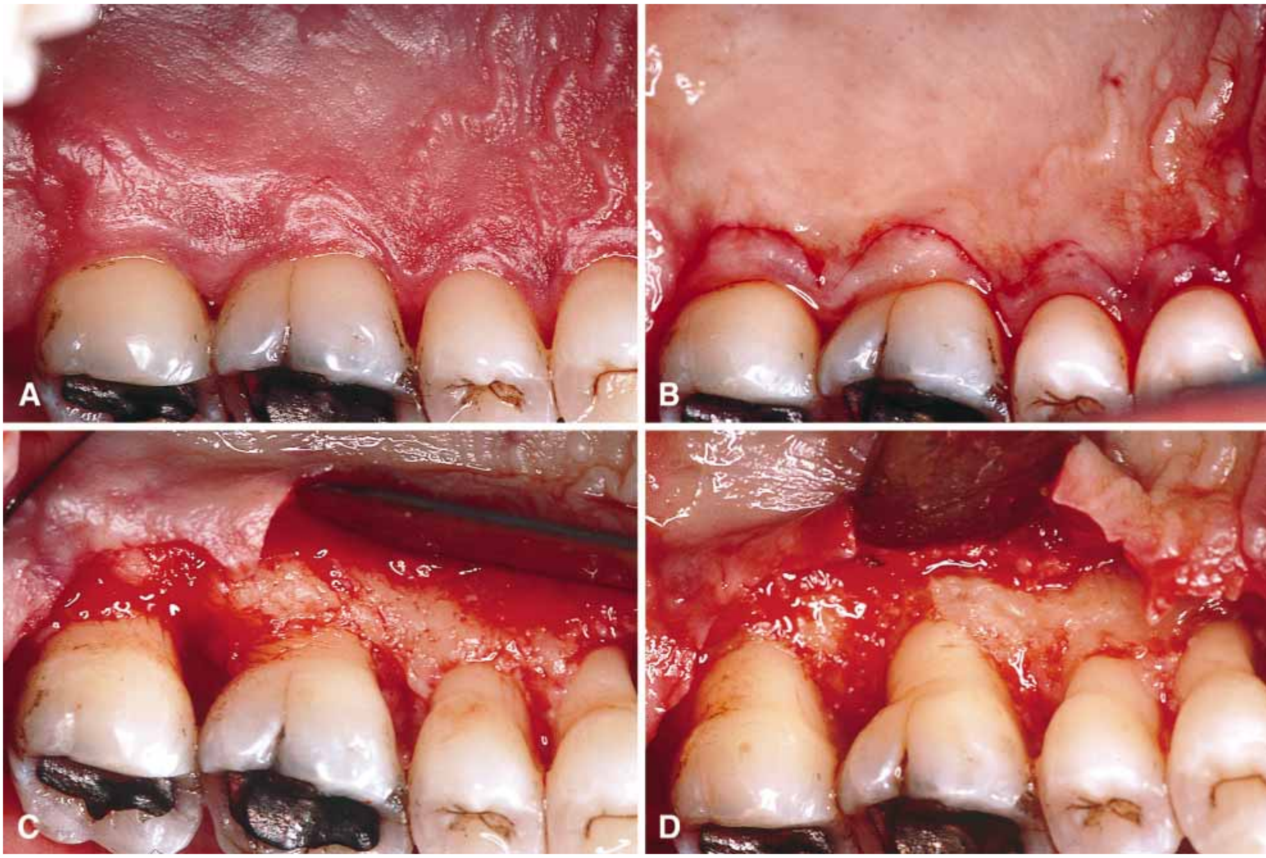


Fig. 9. A. Clinical appearance of maxillary left in a 49-year-old man diagnosed with chronic periodontitis – palatal view. Periodontitis was characterized by interproximal pocket depths of up to 8 mm. B. Palatal scalloped incision starts at a distance from the gingival margin and is aimed apically at the osseous tissue. The scalloped incision removes the inflamed tissue and creates a thin flap margin for adaptation to dentoalveolar unit following osteoplasty and ostectomy. Due to the lack of soft tissue flexibility in the palate, a definitive scalloped incision should be performed. C. Once palatal flap is reflected, direct clinical examination of osseous morphology provides additional diagnostic information to finalize osseous recontouring. Note the presence of our interproximal medium crater. D. Aesthetic osseous surgery eliminated the palatal wall of the osseous defect and palatal ostectomy ensured apical positioning of the radicular osseous crest in relation to the interdental bone. No buccal ostectomy was performed.

bone fill in all osseous lesions, irrespective of their morphological classification.

Contraindications for aesthetic osseous surgery include deep buccal defects, deep craters, deep three-wall defects and deep circumferential defects.

The significance of presurgical plaque control

Prior to osseous surgery, excellent plaque control is indispensable for the restoration of interproximal tissue height. Yumet & Polson (41) reported loss of connective tissue attachment after surgery in the plaque-infected dentition. More mitotic epithelial activity across the wound surface and into the incision is associated with the presence of chronic inflammation in the underlying connective tissue (40, 41). Mediators released from the inflammatory cells in the connective tissue and production of various bacterial toxins and enzymes contribute to further tissue destruction.

The significance of postsurgical plaque control

Following aesthetic osseous surgery, proper plaque control is required to restore and preserve interproximal tissue height. Osseous surgery in patients presenting poor plaque control could result not only in gingival inflammation but also a gradual recurrence of pathologically deepened periodontal pockets (18, 22). Nyman et al. (22) reported an average periodontal attachment loss of 1 mm per year in patients treated by osseous surgery and presenting poor postsurgical plaque control.

Aesthetic periodontal osseous surgery should not be offered to patients who do not meet high standards of oral hygiene (22). Weekly postsurgical recall for 4 to 6 weeks and monthly thereafter for 1 year may be required to insure optimal conditions for periodontal wound healing.

Histogenesis of osseous repair after osteoplasty or ostectomy

At 2 to 3 weeks post-operatively, osseous resorption occurs on the periodontal surface if the osseous plate is thin, and on the osseous surfaces facing marrow spaces and Haversian systems if the osseous plate is thick (40).

Osteoblastic repair activity reaches its peak at 3 to 4 weeks post-surgery. Uncalcified osteoid tissue appears at 3 weeks and forms an immature osseous tissue at the alveolar crest and on the periosteal surface. Replacement by the intermediate type of osseous tissue takes place at 6 months and by mature osseous tissue at 18 months post-surgery. Preserving sufficient osseous thickness enhances osseous repair and anatomical restoration of the operated site (38–40). Loss of 0.5 mm to 1.0 mm of osseous crest may be associated with a thin postoperative osseous tissue (40). Little or no permanent alteration of osseous height is usually associated with the interradicular area (39).

A definitive new periosteum would be evident at 6 months (40). New collagen fiber bundles are embedded in osteoid tissue on the operated periosteal surface by the second month. In the area of the tooth root, the collagen fiber bundles are first parallel to the long axis of the root until the fifth and six months post-surgery when they angle from an apical direction into the root. A layer of cementoid, being apposed for the first time on the root at 2 to 3 months, provides for the angular attachment of the collagen fiber bundles (38–40).

Conclusion

Modern medicine requires consistency in treatment outcomes. Aesthetic osseous surgery is a surgical treatment modality that may be used to effectively eliminate periodontal defects. Aesthetic osseous surgery maintains the coronal aesthetic position of the buccal gingiva, reduces probing depths and stabilizes periodontal attachment levels.

Shallow post-treatment periodontal sites provide reduced risk of future breakdown. Aesthetic osseous surgery improves access to diseased radicular surfaces for daily oral hygiene by the patient and maintenance by the therapist. Post-treatment mechanical access to causative factors by the patient is consistent with the goal of preventive medicine. Also, the main purpose of regular visits to the therapist would be the preservation of the dentition in a state of health, comfort and function, rather than the active treatment of reinfection as a result of residual or recurrent periodontal pockets.

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