
Papilla base incision: a new approach to recession-free healing of the interdental papilla after endodontic surgery

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Abstract

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Aim The purpose of the present study was to describe and evaluate a new incision technique: the papilla base incision.

Methodology Twenty healthy patients referred for surgical treatment of persisting apical periodontitis, who were free of periodontal disease and had intact interdental papillae were included in the study. The preoperative papilla height was recorded by measuring the distance between the contact point and the most coronal point of the papilla. The papilla base flap, consisting of the papilla base incision and two releasing incisions, was used to expose the bone. The papilla base incision consisted of a shallow first incision at the base of the papilla and a second incision directed to the crestal bone, creating a split thickness flap in the area of the papilla base. Further apically a full thickness flap was raised. Following standard root-end resection and filling, flap closure was achieved with microsurgical sutures. The papilla base incision was sutured with 2–3 interrupted sutures, which were removed 3–5 days after the surgery. The experimental sites were evaluated at the conclusion of the surgery, at suture removal and after 1 month, and compared to the preoperative findings. The healing pattern, complications and postoperative recession were recorded. The

experimental sites were observed with a $\times 3$ magnification and graded as to whether a visible scar resulting from the incision could be detected. Twenty experimental sites were analysed.

Results Complete closure of the wound was achieved in all cases after surgery. Except for four patients with delayed healing at suture removal, all other patients displayed rapid healing. No noticeable space was created beneath the contact point area. The change in distance between the reference point and the most coronal point of the papilla comparing the preoperative and the one-month postoperative situation was 0.05 ± 0.39 mm. The probing depth remained within normal limits. One month postoperatively, observation of the incision demonstrated: four sites with a visible incision line (grade 1), in seven sites the incision defect could be partially detected (grade 2) and nine incisions could not be detected (grade 3).

Conclusions In patients with healthy marginal periodontal conditions the papilla base incision allows rapid and predictable recession-free healing following marginal surgical exposure of the soft tissues. One month postoperatively the majority of the incisions were completely or partially invisible. Long-term healing will be studied.

Keywords: apical surgery, flap design, papilla base incision, soft tissue healing, suturing.

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Introduction

Loss of the interproximal dental papillae may cause functional, phonetic and aesthetic problems. Complete and

predictable restoration of lost interdental papillae remains one of the biggest challenges in periodontal reconstructive surgery (Blatz *et al.* 1999). It is therefore imperative to maintain the integrity of the papilla during restorative and surgical procedures.

The interdental papilla is the portion of the gingiva between two adjacent teeth. The interdental papilla was

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at one time considered gingival tissue, roughly pyramidal in shape, with the sole function of deflecting food debris. In reality the function of the papilla is more complex and it is a biologic barrier to protect periodontal ligament, cementum and alveolar bone from the oral environment (Caton 1989). It is important to respect the integrity of the papilla during dental treatment and it may be advantageous to achieve keratinization by interproximal brushing to increase the resistance of the col area (Checchi *et al.* 1989).

The presence or absence of the interdental papilla depends upon the distance between the contact point to the crest of bone (Tarnow *et al.* 1992). When the distance from the contact point to the bone was 5 mm or less, the papilla was present almost 100% of the time. With a distance of 6 mm, the papilla was present 56% of the time, and when the distance measured 7 mm or more, the papilla was present 27% of the time or less.

Traditional periodontal surgical treatment opens the interproximal spaces, causing flattening or cratering of the interdental papilla. When a full thickness flap is raised during periodontal surgical treatment in an area with shallow pockets (1–3 mm), loss of attachment results, whereas with deep pockets the attachment level can be maintained or even gained. Re-evaluation after 6.5 years postsurgery found sustained attachment loss in shallow pockets (Pihlstrom *et al.* 1983).

In anterior periodontal surgery a papillary retention procedure is advocated to maintain the papillary height to maximize postoperative aesthetics (Michaelides & Wilson 1996). Cortellini *et al.* (1995, 1996) suggested a modification of the papilla preservation technique, which allows primary closure of the interdental space over a bioresorbable membrane. A horizontal incision at the base of the papilla is performed and the papilla subsequently elevated to the buccal side. After coronal repositioning of the buccal flap over the membrane, the interproximal area is covered with the papilla attached to the lingual flap. Primary closure over the membrane was obtained in all treated sites using the modified preservation technique. Probing attachment level gains and pocket depth reduction were observed after 1 year using this technique.

More recently, periodontal surgical procedures around teeth and dental implants have been used to prevent or correct anatomical, developmental, traumatic or plaque-induced defects of the gingiva. Some of the currently available techniques deal with crown lengthening, alveolar ridge preservation and augmentation, soft tissue grafts and the correction of open interproximal spaces. Soft tissue abnormalities, with the exception of the loss of

the interproximal papilla, can be resolved predictably, improving aesthetics and even creating restorative opportunities (McGuire 1998). The functional and especially aesthetic outcome of all periodontal procedures that aim for hard and soft tissue augmentation is technique sensitive. Application of plastic surgery principles is mandatory to achieve satisfactory results. Passive and tension-free wound closure is fundamental for predictable healing results (Pini Prato *et al.* 2000). Hurzeler & Weng (1999) suggested a series of incisions, buccal and lingual flaps split several times, resulting in a double-partial thickness flap. In this way several tissue layers are obtained and the passive coronal advancement of flaps becomes possible for the coverage of augmented areas. A multilayer wound closure with microsurgical suture material allows perfect adaptation without any tension on the tissue and dependable positioning of the marginal gingiva.

Endodontic surgery requires exposure of the bone covering the root(s) and the apices. To achieve access, a full thickness flap must be raised, which consists of gingival and mucosal tissue as well as periosteum. To mobilize the flap, various modes of incisions can be selected including horizontal incisions (sulcular and submarginal) and vertical releasing incisions (Gutmann & Harrison 1991a).

Although microsurgical techniques have been applied in endodontic surgery for several years, little attention has been given to soft tissue healing following treatment. There is also little scientific and clinical data on recession of soft tissues during healing, specifically papilla healing, when no pathological changes are present in the periodontal tissues. The care of the healthy periodontal tissues is a very challenging one and it is of utmost importance to prevent attachment loss and recession of the gingiva following endodontic surgery. Even partial loss of the papilla should be avoided, as predictable correction of the interproximal papilla height is difficult.

In periapical surgery the sulcular full thickness flap is often used (Beer *et al.* 2000). During the marginal incision the scalpel is in constant and direct contact with the tooth and will sever sulcular epithelium and connective tissue fibres of the gingiva, leaving some attached epithelium and connective tissue on the root surface. This tissue is very delicate and can be injured easily, which may delay healing (Harrison & Jurosky 1991). The attached tissue on the root surface must not dry out or be disturbed during flap manipulation as it facilitates the epithelial and connective tissue reattachment. Ideally, the sulcular incision should dissect the buccal from the lingual papilla. In narrow interproximal spaces complete mobilization of the papilla is often difficult causing tissue

loss. Shrinkage of the papilla during the healing phase can occur, and may cause the ultimate loss of papilla height. Zimmermann *et al.* (2001), in a preliminary study, investigated the shrinkage of the papilla after sulcular flaps in patients with healthy periodontal tissues. The loss of height of the papilla increased gradually during healing. Immediately postoperatively the loss of papilla height due to surgical manipulation resulted in 14 sites with a recession within one-quarter and three sites between one-quarter and one-half of the original height. At suture removal the papillae exhibited six sites with a loss of height of up to one-half the original position. None of the 17 sites remained at preoperative levels at any time. These results suggest that the conventional sulcular flap results in moderate, progressive retraction of the papilla.

To prevent the marginal recession of the gingiva, a submarginal incision was suggested (Luebke 1974). This incision is made within the attached gingiva parallel to the marginal contour of the gingiva. The submarginal flap is advocated when there is a broad band of attached gingiva and the expected apical lesion or surgical bony access will not extend to the incision line. This flap design preserves the marginal gingiva and does not expose the crestal bone. In maxillary anterior areas the submarginal incision is preferred in situations with subgingivally placed margin of crowns and bridge-work. The main disadvantages of the submarginal incision are the scar formation due to flap shrinkage (Kramper *et al.* 1984), delayed healing and possible marginal tissue necrosis, when an insufficient blood supply is present.

Though sulcular flaps remain the most frequently used in endodontic surgery (Beer *et al.* 2000), the main disadvantage of these are recession and, especially, unpredictable shrinkage of the papilla during healing (Zimmermann *et al.* 2001), although Chindia & Valderhaug (1995) found no difference in attachment loss between trapezoidal and semilunar flaps in apicoectomy.

A persisting endodontic infection following periradicular surgery may be regarded as a contributing risk factor for a progressing marginal attachment loss (Jansson *et al.* 1997). The mean clinical attachment loss in teeth with an unsuccessful healing was 0.85 mm and differed significantly from successfully healed cases with a mean of 0.15 mm.

A new incision for the marginal mucoperiosteal flap was designed to prevent loss of interdental papilla height. The technique involves the preservation of the entire papilla, thus eliminating any potential loss of height as a result of the surgical or healing process. The purpose of

the study was to describe and evaluate a novel marginal incision technique – the papilla base incision, which preserves the integrity of the interdental papilla during and after endodontic surgery in cases where there is no evidence of marginal periodontitis.

Materials and methods

Twenty patients (eight women and twelve men) in good general health referred for surgical treatment of persistent apical periodontitis were included in the study. The age of the patients ranged between 25 and 80 years, with a mean age of 47.8 ± 13.6 years. The teeth consisted of mandibular and maxillary anteriors, premolars and molars (Table 1). All teeth had previously been root filled at various times and with different methods, but all were failing with persisting symptoms, and/or apical radiolucency. A conventional retreatment had either been performed and failed, or was not feasible because of canal obstruction, or the patient refused to sacrifice the coronal restoration for retreatment. Only patients without signs of periodontal disease were included in the study. Periodontal health was defined as absence of bleeding on probing and probing depths not exceeding 3 mm on any of the teeth in the area of the surgery. Interdental papillae were occupying the interproximal space below the contact area.

All teeth were anaesthetized with 4% articaine with 1 : 100 000 adrenaline infiltration and in the designated flap area additionally lidocaine with 1 : 50 000 adrenaline was administered for profound haemostasis. A mandibular block together with infiltration anaesthesia was given for the mandibular teeth and for maxillary teeth only infiltration anaesthesia was applied. The entire surgical procedure was performed with microsurgical instruments and magnified vision of at least 4.3 ×, using loupes and an operating microscope.

The papilla base flap consisted of two releasing vertical incisions, connected by the papilla base incision and intrasulcular incision in the following way. Initially, the vertical incisions were placed at least one tooth distal and mesial to the tooth to be treated. The marginal incision started with the preparation of the papilla base

Table 1 Frequency distribution of treated teeth according to tooth type

Tooth type	Maxillary	Mandibular
Anteriors	5	1
Premolars	1	1
Molars	4	8

incision using a microsurgical blade (BB 369, Aesculap, Tuttlingen, Germany). The 2.5 mm wide blade with a round configuration at the tip has cutting edges on both sides and all around the tip. The papilla base incision required two different incisions at the base of the papilla.

1 The first shallow incision severed the epithelium and connective tissue to the depth of 1.5 mm from the surface of the gingiva. The incision was placed at the level of the lower third of the papilla in a slight curved line going from one side of the papilla to the other (Fig. 1). The incision started and ended in a 90 degree angle between the border of the tooth and the gingiva (see lines in Fig. 1).

2 The scalpel was then placed to the base of the previously created shallow incision at the base of the papilla and subsequently inclined apically, almost parallel to the long axis of the tooth, aiming at the crestal bone margin. With this second incision a split thickness flap was prepared in the apical third of the base of the papilla. The incision ended at the crestal bone level, where the periosteum was separated from the bone (Fig. 2). From there on the preparation continued in a full thickness muco periosteal flap (Fig. 3). Buccally over the tooth the vertical incision and papilla base incision were joined by an intrasulcular incision. The scalpel was moved within the sulcus, dissecting the gingiva to the crestal bone. The sulcular incision reached from the releasing incision to the start of the papilla base incision,



Figure 1 Papilla base flap consisting of two releasing incisions and the papilla base incision. The papilla base incision is placed in the lower third of the interdental papilla. The incision starts and ends at a 90 degree angle (see lines) to the gingival margin, resulting in a curved line at the base of the papilla.

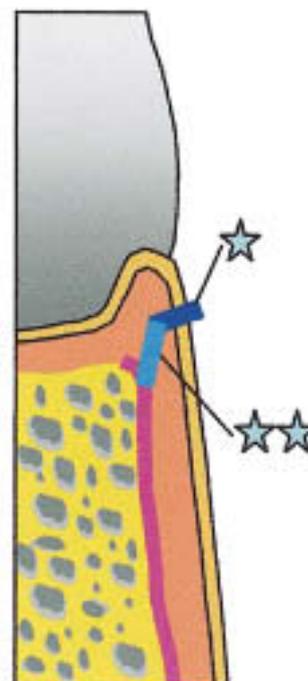


Figure 2 Schematic drawing of the longitudinal section through the interdental papilla. *marks the initial shallow incision through the epithelium and connective tissue to the depth of 1.5 mm. **demonstrates the second incision directed to the crestal bone. The scalpel blade is inserted into the base of the first incision and directed nearly parallel to the long axis of the tooth. The second incision will prepare a split thickness flap reaching from the first incision to the crestal bone level.

or from one papilla to the next papilla. The flap was mobilized and retracted, during the root-end resection and filling.

The flap closure was initiated from the releasing incisions. For the vertical incisions 6/0 (Supramid, B. Braun, Neuhausen, Switzerland) interrupted polyamide sutures were used. The papilla base incision was sutured with two or three polypropylene 7/0 (Prolene, Ethicon, Nordestedt, Germany) interrupted sutures depending on the width of the papilla. Great care was taken in passive reapproximation and perfect adaptation of the wound margins without tension to the sutures (Fig. 4a). The flap was compressed for 1 min at the conclusion of the surgery. Patients were instructed to apply a cold compress to the face for 10 min every 30 min for the rest of the day and were prescribed NSAID (Ponstan, Parke Davis, Baar, Switzerland), 250 mg three times per day for 48 h. Following this, patients only took the analgesics when required. Patients were instructed to refrain from mechanical oral hygiene in the operated area and rinse



Figure 3 Clinical photograph after complete reflection of the papilla base flap. Note the elevated split thickness flap from the incision to the crestal bone level. Apical to the crestal bone area the full thickness flap exposes the bone over the roots.



Figure 4 (a) Wound closure of the papilla base incision with three polypropylene sutures; (b) sutures removed after 4 days.

twice daily with 0.2% chlorhexidine during the first week after the surgery. The sutures were removed 3–5 days post operatively (Fig. 4b).

Twenty sites were evaluated. The surgical areas were photographed perpendicularly to the interproximal area:



Figure 5 Incomplete healing. Clearly detectable incision wound. (a) Post surgery; (b) healing at 1 month.

- 1 before surgery;
- 2 immediately postoperatively;
- 3 at 3 to 5 days after suture removal; and
- 4 at a recall appointment 1 month postoperatively.

Great care was taken to maintain the same angulation and magnification of the photographs. The photographs were digitized in a slide scanner (LS 2000, Nikon Corporation, Japan), imported as TIFF files into the Photoshop 6.0 (Adobe Systems Incorporated, USA) and the pictures enlarged to 3× magnification. The images were compared for increase of the space between the papilla and contact area as a sign of loss of height. The change of the position of the most coronal point of the papilla was determined by measuring the distance between a reproducible point on the tooth and papilla tip using a perio probe. The precision of the measurement reading was an approximation to 0.5 mm. Wound healing complications, such as excessive swelling, infections, wound dehiscence and necrosis, were recorded at all times. Probing depths were measured at recall appointments, except at the suture removal.

One month post operatively the experimental sites were observed with a 3× magnification and graded as to whether a visible defect resulting from the incision could be detected. Incomplete healing (grade 1) described a clearly visible defect along the entire incision (Fig. 5b). Partially complete healing (grade 2) was noted, when parts of the incision were visible and at the same time there were also areas with undetectable healing patterns (Fig. 6b). Perfect healing (grade 3) was given for undetectable incision lines (Fig. 7b).

Results

Complete closure of the wound was achieved in all cases and no severe complications such as papilla necrosis



Figure 6 Partially complete healing. There are areas in which the incision can be still detected, whereas in other parts the healing is undetectable. (a) Post surgery; (b) healing at 1 month.



Figure 7 Perfect healing. The place of the incision can not be detected. (a) Post surgery; (b) healing at 1 month.

occurred. One patient exhibited delayed healing at suture removal along the entire margin of the flap, leading to visible and persistent scar formation. Three other patients displayed irritation around the sutures at the time of their removal (Fig. 8b). Further healing in these patients was uneventful (Fig. 8c). All other patients displayed rapid healing.

The photographs did not reveal any noticeable opening of the space between the papilla and contact area as a result of the loss of papilla height at any observation time. The mean difference between a reference point and the most coronal point of the papilla comparing the preoperative and the one-month postoperative situation was 0.05 ± 0.39 mm. None of the patients exhibited probing depths greater than 3 mm at one month. The visual observation of the incisions at this recall demonstrated



Figure 8 Tissue irritation at suture removal. (a) Post surgery; (b) before suture removal; (c) healing at 1 month.

four sites with visible defects (grade 1), seven sites with partially detectable incision defect (grade 2) and nine sites with perfect healing (grade 3).

Discussion

It is of utmost importance to preserve epithelial and connective tissue attachment at its original level and traumatize the attachment apparatus as little as possible during the incision in order to obtain rapid healing through primary intention. This can be obtained by:

- 1 complete and sharp incision of the tissues;
- 2 avoiding crushing of the tissues;
- 3 preventing drying of the tissues during the procedure; and
- 4 perfect adaptation of wound edges upon closure (Gutmann & Harrison 1991b).

Recession of the papilla after sulcular incisions has not been discussed recently. It remains however, an important problem, which cannot be corrected in a predictable manner. Although advanced restorative procedures and materials have expanded the therapeutic options, anterior hard and soft tissue deformities continue to represent a significant technical and aesthetic challenge (Salama *et al.* 1998). When semilunar flaps were compared with trapezoidal flaps, no statistically significant change was observed in pocket depth or attachment levels (Chindia & Valderhaug 1995). In another study, despite microsurgical techniques, the mobilization of the papilla resulted in considerable loss of height after 3–5 days (Zimmerman *et al.* 2001). Besides aesthetic disadvantages, this may create biological and phonetic problems, as well as food impaction. The height of the papilla depends on the distance between the contact point and crestal bone. In a healthy periodontium without any attachment loss, the papilla fills the entire interproximal space between two teeth in almost all instances (Tarnow *et al.* 1992). In periodontally healthy sites, particularly when subgingivally placed crown margins are present, recession is a

risk when a surgical procedure is required to treat apical pathology. With the papilla base incision it is possible to prevent any noticeable recession of the papilla following apical surgery. The mean change in distance of the most coronal point of the papilla between the preoperative and the one-month postoperative situation was 0.05 mm. The standard deviation of ± 0.39 is most likely due to the measurement technique used. This involved the measurement of the distance with periodontal probe with an approximation to 0.5 mm. It seems that the dimensional changes are less than the precision of the measurement used.

Although the papilla base incision achieved very predictable results, this technique is challenging to perform. First, atraumatic handling of the soft tissues is mandatory to obtain good results. Secondly, two different incisions are needed for good healing and to avoid excessive scar formation or an indentation at the site of the incision. The first shallow incision (1.5 mm) into the tissue will prevent thinning of the coronal aspect of the flap. Thin tissue fins, unsupported by connective tissue, will necrotize and create a defect, which will be repaired by visible scar tissue. The remaining papilla, as well as the raised flap, should be treated with great care, kept moist, and held in place without pressure during suturing. In addition, fine (7/0, preferably 8/0), non-resorbable and tissue tolerated polypropylene suture material should be used to avoid further irritation to the wound margins. The delicate atraumatic needles cause minor injury to the papilla and flap, provided the tissues are not pinched several times during suturing. Finally, the wound edges are perfectly reapproximated without tension on the suture. Tension will compromise blood circulation on both the papilla and the split flap and cause delayed healing. It was shown by Pini Prato *et al.* (2000) that greater tension reduced root coverage in coronally advanced flaps. Split flaps are routinely used in periodontics. They are applied in mucogingival surgery for subepithelial grafting, augmentation, recession coverage and papilla reconstruction after implant placement.

The number of sutures needed for securing the papilla base flap to the papilla depends on the width of the papilla. A minimum of two sutures is required, one at each side of the papilla base incision for perfect reapproximation of the wound edges. An additional suture will secure close adaptation of the flap, when necessary.

In the buccal cervical area an intrasulcular incision is performed. The scalpel size has to be small enough to move the blade within the sulcus and not cut into the gingiva. Although the scalpel is in constant contact with the tooth, the incision will sever sulcular epithelium and

fibres of the connective tissue, leaving some root attached epithelium and connective tissue on the root surface. This tissue is very delicate and can be injured easily, which will delay the healing (Harrison & Jurosky 1991). The attached tissue on the root surface must not dry out, as it facilitates the epithelial and connective tissue reattachment. In the present clinical study, although papilla height could be maintained at its preoperative levels, some recession was noted in the cervical area.

A submarginal incision is often preferred when crowns and bridges are present. The Ochsenbein Luebke flap will preserve the marginal gingiva and will not expose the crestal bone. The blood supply to the marginal tissues is supplied from the crestal bone area and through the papilla from the lingual side. Unfortunately, this flap design cannot always be used, as a minimum of 2 mm of attached gingiva should be present coronal to the prospective line of the incision (Lang & L oe 1972). In addition, the presence of periodontal pockets usually prevents the use of this technique. The main disadvantage of the Ochsenbein Luebke flap is the unpredictable scar formation (Kramper *et al.* 1984) and the devastating complication of marginal gingival necrosis (personal observation).

A review of the literature indicates a loss of clinical attachment following periodontal flap procedures for shallow pockets (1–3 mm), and sustained attachment loss after modified Widman flap after 6.5 years (Pihlstrom *et al.* 1983). Probably, part of the attachment loss in these studies occurred because of scaling and root planing during the surgical periodontal treatment. The scaling and root planing removes epithelial and connective tissue attachment, which needs to be reformed, resulting in some attachment loss. In endodontic access flaps no scaling and root planing is performed. The aim of the soft tissue management in apical surgery is to prevent attachment loss and recession of the marginal periodontium, especially when healthy conditions are present.

Based on the results of this study, the recession of the papilla in healthy periodontal sites can be prevented during apical surgery. The papilla base incision displayed excellent healing without noticeable loss of height of the papilla. The mid-term healing of the incision at the base of the papilla was either invisible or slightly visible for the majority of the sites. Only four sites displayed a distinct line of indentation or separation visible at 3 \times magnification 1 month after the surgery. Subjectively, none of the patients with visible graded healing noted any disadvantage aesthetically. Further study will analyse the long-term healing in papilla base incisions and compare it to

standard elevation of the papilla in marginal full thickness flaps.

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References

- Beer R, Baumann MA, Kim S (2000) *Endodontology*. Stuttgart: Thieme Verlag, 238–9.
- Blatz MB, Hurzeler MB, Strub JR (1999) Reconstruction of the lost interdental papilla—presentation of surgical and non surgical approaches. *International Journal of Periodontics and Restorative Dentistry* **19**, 395–406.
- Caton J (1989) Periodontal diagnosis and diagnostic aids. In: Nevins M, Becker W, Kornmann K, eds *Proceedings of the World Workshop in Clinical Periodontics*. Chicago, IL, USA: The American Academy of Periodontology, I-1–I-22.
- Checchi L, Zelent ME, Rizzi GP, D'Achille C (1989) Normality and pathology of the interdental papilla. *Dental Cadmos* **57**, 83–92.
- Chindia ML, Valderhaug J (1995) Periodontal status following trapezoidal and semilunar flaps in apicectomy. *East African Medical Journal* **72**, 564–7.
- Cortellini P, Pini Prato G, Tonetti MS (1996) The modified papilla preservation technique with bioresorbable barrier membranes in the treatment of intrabony defects. Case reports. *International Journal of Periodontics and Restorative Dentistry* **16**, 546–59.
- Cortellini P, Prato GP, Tonetti MS (1995) The modified papilla preservation technique. A new surgical approach for interproximal regenerative procedures. *Journal of Periodontology* **66**, 261–6.
- Gutmann JL, Harrison JW (1991a) *Surgical Endodontics*, 1st edn. Boston, MA, USA: Blackwell Scientific Publications, 153–82.
- Gutmann JL, Harrison JW (1991b) *Surgical Endodontics*, 1st edn. Boston MA, USA: Blackwell Scientific Publications, 300–37.
- Harrison JW, Jurosky KA (1991) Wound healing in the tissues of the periodontium following periradicular surgery. I. The incisional wound. *Journal of Endodontics* **17**, 425–35.
- Hurzeler MB, Weng D (1999) Functional and esthetic outcome enhancement of periodontal surgery by application of plastic surgery principles. *International Journal of Periodontics and Restorative Dentistry* **19**, 36–43.
- Jansson L, Sandstedt P, Läftman ACH, Skoglund A (1997) Relationship between apical and marginal healing in periradicular surgery. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology and Endodontics* **83**, 596–601.
- Kramper BJ, Kaminski EJ, Osetek EM, Heuer MA (1984) A comparative study of wound healing of three types of flap design used in periapical surgery. *Journal of Endodontics* **10**, 17–21.
- Lang NP, Löe H (1972) The relationship between the width of keratinized gingiva and gingival health. *Journal of Periodontology* **43**, 623–7.
- Luebke RG (1974) Surgical endodontics. *Dental Clinics of North America* **18**, 379–91.
- McGuire MK (1998) Periodontal plastic surgery. *Dental Clinics of North America* **42**, 411–65.
- Michaelides PL, Wilson SG (1996) A comparison of papillary retention versus full-thickness flaps with internal mattress sutures in anterior periodontal surgery. *International Journal of Periodontics and Restorative Dentistry* **16**, 388–97.
- Pihlstrom BL, McHugh RB, Oliphant TH, Ortiz-Campos C (1983) Comparison of surgical and nonsurgical treatment of periodontal disease. A review of current studies and additional results after 6 1/2 years. *Journal of Clinical Periodontology* **10**, 524–41.
- Pini Prato G, Pagliaro U, Baldi C *et al.* (2000) Coronally advanced procedure for root coverage. Flap with tension versus flap without tension: a randomized controlled clinical study. *Journal of Periodontology* **71**, 188–201.
- Salama H, Salama MA, Garber D, Adar P (1998) The interproximal height of bone: a guidepost to predictable aesthetic strategies and soft tissue contours in anterior tooth replacement. *Practical Periodontics and Aesthetic Dentistry* **10**, 1131–41.
- Tarnow DP, Magner AW, Fletcher P (1992) The effect of the distance from the contact point to the crest of bone on the presence or absence of the interproximal dental papilla. *Journal of Periodontology* **63**, 995–6.
- Zimmermann U, Ebner JP, Velvart P (2001) Papilla healing following sulcular full thickness flap in endodontic surgery. *Journal of Endodontics* **27**, 219 [Abstract OR19].