Preservation of the Interimplant Papilla in the Esthetic Zone

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It is widely recognized that an esthetically pleasing appearance of the teeth is highly dependent on the state of health and the contours of the surrounding soft tissues. Esthetic soft tissue contours include a harmoniously scalloped gingival line; the avoidance of abrupt vertical differences in clinical crown lengths between adjacent teeth; a convex buccal mucosa of sufficient thickness; and distinct papillae.[1-3]

Tooth extraction causes injury to and disintegration of the surrounding hard and soft tissues, often resulting in the collapse of the alveolar ridge topography.[4-7] In most cases, the residual ridge deformation becomes a problematic site that is difficult to restore, functionally as well as esthetically, by a "conventional" tooth-supported restoration or by an implant-anchored restoration. A variety of surgical, prosthetic, and orthodontic techniques for successful preservation or restoration of a natural-looking alveolar ridge prior to, simultaneous with, or following single-tooth implant placement have been developed in the last decade.[8-30]

However, it has been well documented that the ability to restore and maintain the health, function, and esthetics of soft tissues around a single implant restoration depends mainly on the integrity of the attachment apparatus of the adjacent teeth (Fig 13-1).[31-34]

The flattening and narrowing of the ridge, accompanied by the almost complete disappearance of the interproximal papillae, may follow the extraction of two or more adjacent teeth. These aggressive topographic changes occur as a result of local complete disruption of adjacent interwoven collagen fiber systems that normally function as the supportive network required to maintain function and form in hard and soft tissues around natural teeth. Although the reconstruc-

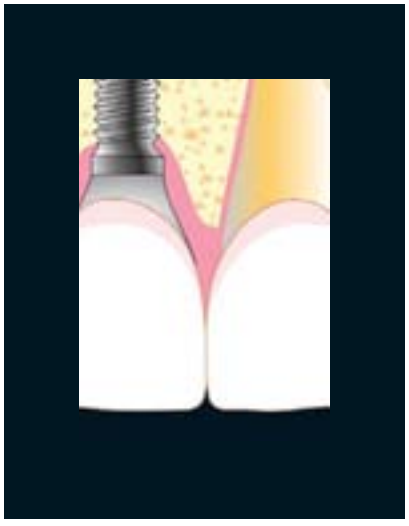


Fig 13-1 The presence of a "perfect" papilla next to an implant depends mainly on the height of crestal bone on the adjacent tooth.

tion of both the horizontal and vertical dimensions of the ridge around properly placed, prosthetically driven dental implants may be predictably achieved,[35–37] the preservation or restoration of interimplant papilla following the extraction of two adjacent teeth remains one of the most difficult challenges in esthetic dentistry.[1,27–29,33,38,39]

This chapter describes the application of socket seal surgery,[9,11] in conjunction with prosthetic soft tissue guidance,[23,25,40–43] to preserve the interimplant bone and the papilla during replacement of the maxillary central incisors with implant-supported restorations.

Case Report

A 45-year-old woman desired replacement of her old maxillary anterior crowns with esthetically pleasing new restorations that would maintain the size, shape, and character of the existing crowns. Her medical history was noncontributory.

A clinical examination revealed severely inflamed gingival margins with reduced interdental papillae height associated with small, square, ill-fitting crown restorations (Fig 13-2a). Probing of the shallow pockets associated with the incisor teeth was likely to provoke bleeding. The gingival phenotype was evaluated as thick and flat.

A radiographic examination revealed the short, apically resorbed roots of the central incisor teeth and the cervically carious root of the left lateral incisor tooth. Inter-root distances were found to be bigger than normal while crestal bone profiles were slightly reduced. A minor periapical radiolucency was associated with the left central incisor. Crestal bone profiles in the maxillary anterior region were found to be normal (Fig 13-2b).

Fig 13-2a At presentation, square, ill-fitting crowns on the incisor teeth are associated with chronically inflamed gingiva.
Fig 13-2b At presentation, the radiograph reveals periapical pathoses associated with both the central incisors and the left lateral incisor.

Case evaluation

The prognosis of the central incisors and the left lateral incisor as adequate long-term supporters for the new restorations was considered poor, and the patient was informed of the need to extract the teeth. To increase anterior occlusal support and to optimally preserve the anterior ridge topography, an implant-supported restoration was suggested. This plan was accepted by the patient.

However, the patient declined the use of any tissue-borne prosthesis in the provisional stages of therapy. She was informed that, to allow immediate restoration of her lost anterior dentition with a fixed transitional restoration, her canine teeth would require preparation as abutment teeth. The use of an immediately functioning implant-supported restoration was not considered because at the time of treatment initiation (1995), insufficient scientific and clinical data were available to support this treatment modality.

Treatment sequence

Presurgical provisionalization

Following removal of the ill-fitting fixed partial denture, the maxillary right canine and lateral incisor and the left canine and first premolar were endodontically treated and received cast-gold posts and cores. The carious crowns of the teeth to be removed were ground subgingivally to receive a seven-unit transitional fixed partial denture that included three ovate pontics. Two weeks later, on the day of surgery, there was a marked reduction in the inflammatory state of the gingival margins and the interdental papillae, as expected (Figs 13-2c and 13-2d).

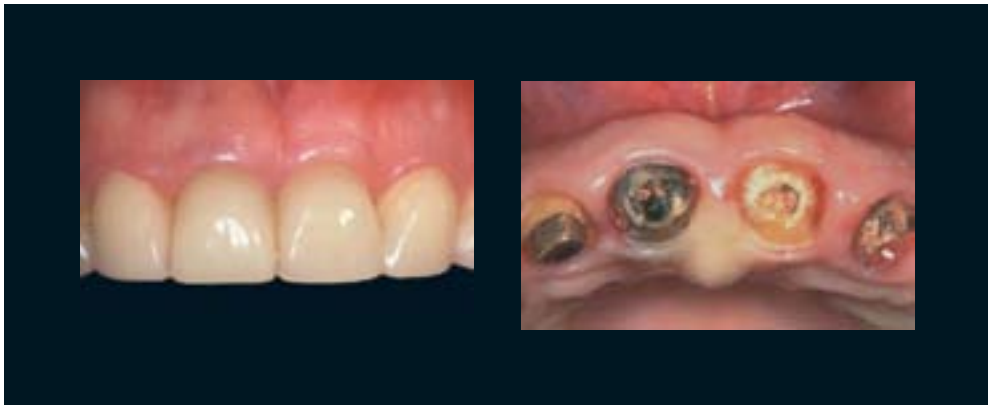


Fig 13-2c Provisional fixed partial denture the day of surgery. Interdental papillae are supported by the approximating surfaces of ovate pontics.
Fig 13-2d Right and left central incisors and left lateral incisor immediately before extraction. The carious roots have been ground subgingivally.

Preoperative medication regimen

Prophylactic antibiotics (amoxycycline, Teva Pharmaceuticals, Israel) were used 1 day presurgery and 4 days postsurgery. Anti-inflammatory analgesics (naproxen sodium, 500 mg) were given 1 hour presurgery and 4 times daily as needed postsurgery. The patient was also sedated with diazepam 1 hour before surgery.

Following thorough cleansing of the teeth, the patient was instructed to use a 0.2% chlorhexidine mouthrinse immediately before a local anesthetic was administered (lidocaine 2% with epinephrine 1:100,000).

Implant placement combined with socket seal surgery

Following gentle flapless extraction of the maxillary central incisors and the left lateral incisor (Fig 13-2e), the fresh sockets were thoroughly debrided of granulation tissue and residual periodontal ligament fibers. The socket bony walls (except for the labial walls) were further decorticated, using a thin (1.0 mm in diameter) cylindrical carbide bur to increase the participation of the endosteal bone-forming cells in the wound (Fig 13-2f).

The gingival walls at the socket orifice were gently de-epithelialized by a water-cooled, high-speed, coarse round diamond bur (2.0 mm in diameter), thereby exposing the vascularized lamina propria responsible for nourishing and revascularizing the soft tissue graft to be placed later at the socket orifice.

To avoid perforation of the gingival walls of the socket, care was taken not to overthin them. At this stage, the sockets were evaluated for the presence and the integrity of the remaining bony walls.

Except for the labial wall at the left lateral socket, of which very little remained, the remaining socket walls were mostly intact.

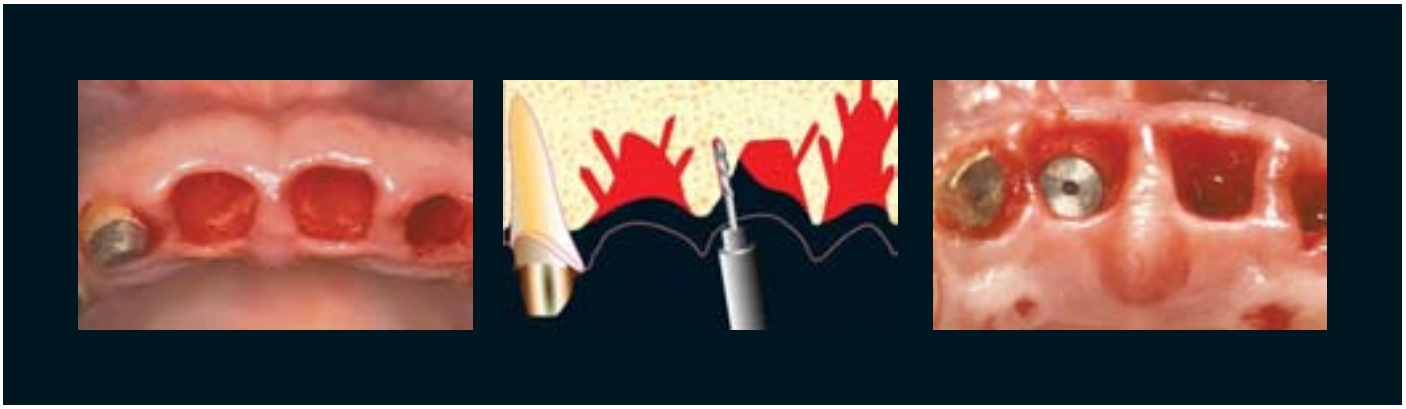


Fig 13-2e Extraction sockets immediately after the flapless extraction. The bony walls are debrided and decorticated. The internal gingival walls are de-epithelialized.
Fig 13-2f A thin, cylindrical carbide bur decorticates the bony walls to increase the participation of endosteal bone-forming cells in the healing socket.
Fig 13-2g The gap created between the implant and labial plate of the right central incisor site is grafted with autogenous bone particles.

Immediate implant placement, in combination with the socket seal surgery as previously described,[11] was considered an adequate surgical approach for the central incisor sites only. The site of the lateral incisor was preserved with socket seal surgery but without implant placement.[9] For optimal prevention of bacterial contamination during implant placement, the sockets were treated sequentially. A 4.0-mm-diameter and 15.0-mm-long threaded implant (Brånemark Mark II, Nobel Biocare, Gothenburg, Sweden) was placed centrally in the socket orifice of the right central incisor site. The provisional fixed partial denture was used as a guide. To avoid penetration of the labial wall, the axis of the implant was directed slightly toward the palatal wall. The implant head was placed about 1.5 mm palatal to the labial soft tissue margins.

The minimal space created labially and interproximally around the implant was grafted with autogenous bone collected by the implant drills from the fresh socket. Care was taken to prevent the deposition of bone particles on the soft tissue walls (Fig 13-2g). A circular and cylindrical 2.5-mm-thick soft tissue graft that contained residuals of the fatty submucosa was obtained from the palate. The diameter of the graft was slightly greater than the diameter of the socket orifice, to allow firm adaptation to the socket's soft tissue walls. The socket-sealing graft was secured by six simple 4-0 silk sutures placed circumferentially, each passing through the graft and the gingival wall.

Implementing similar surgical steps at the left central incisor site, which was treated next, necessitated minor changes in the surgical protocol:

1. The drills only slightly penetrated the labial plate at a depth of 13 mm because of the accentuated concave pattern of the alveolar bone at this site. To maintain an implant axis similar to that of the adjacent implant, a shorter implant (13 mm in length, 4 mm in diameter) was placed. Its apex seemed to minimally lift up the periosteum because there was only light penetration of the labial plate.
2. Because a suspected minor inflammatory process was noted at the root apex, no bone was collected from the site for grafting in the spaces created between the implant and the surrounding bony walls.

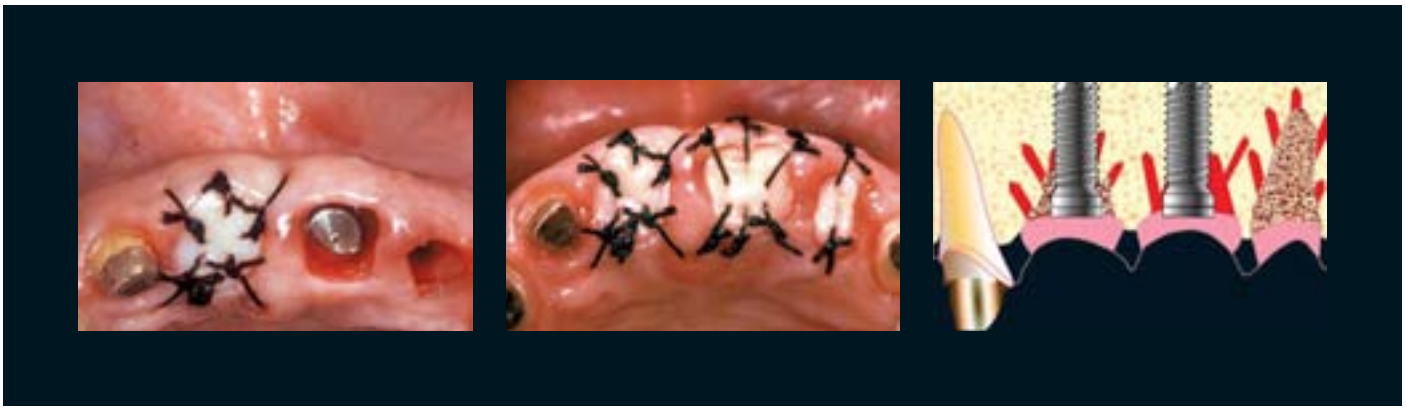


Fig 13-2h A mucosal graft is sutured over the implant placed in the extraction socket of the right central incisor. An implant is placed in the socket of the left central incisor. No bone particles are grafted in the gap between the implant and the bony walls of the left central incisor site.
Fig 13-2i Mucosal grafts are sutured over the implants at the central incisor sites and over the bone graft at the left lateral incisor socket.
Fig 13-2j The soft tissue grafts seal the sockets, allowing optimal conditions for bone maturation around the implants and inside the nonimplanted socket.

At the final stage, the left lateral incisor extraction socket was treated for ridge preservation using socket seal surgery without implant placement, as previously described (Figs 13-2h to 13-2j).

Postsurgical provisionalization

Following completion of the implant surgery, a light-cured acrylic resin was added to the cervical part of the three pontics to obtain an optimally ovate shape. This was intended to provide initial support for the labial soft tissue margins as well as the interproximal papillae once the fixed partial denture had been reseated.[23,40–43] However, to prevent compromising the plasmatic circulation imperative for initial nourishment of the grafted tissue, care was taken not to exert pressure on the underlying soft tissue graft and the surrounding gingiva (Figs 13-2k and 13-2l).

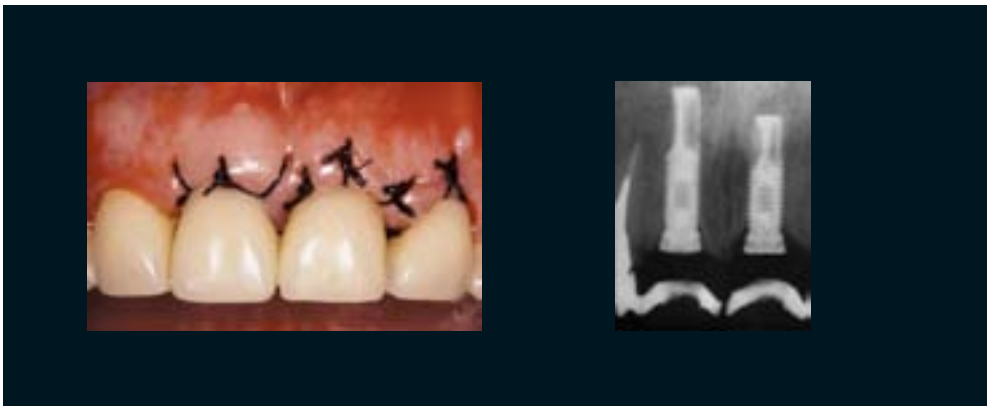


Fig 13-2k The provisional fixed partial denture is immediately placed with minimal pressure on the mucosal graft to support the interproximal papillae.
Fig 13-2l Radiographic view immediately after implant placement and cementation of a metal-reinforced transitional restoration.

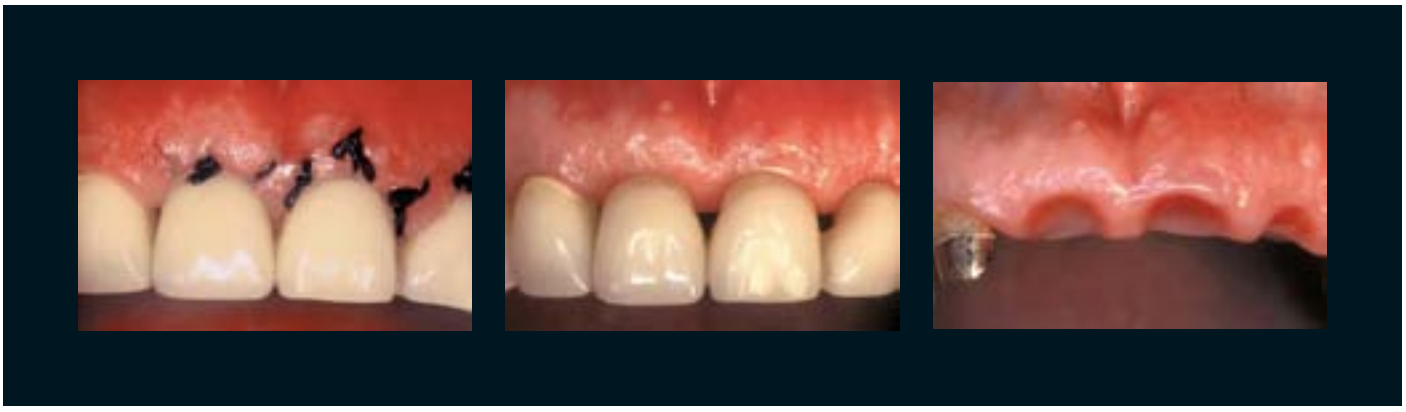


Fig 13-2m One week postsurgery, the ovate pontics are supporting a nice soft tissue configuration. The central papilla seems to enlarge coronally.
Fig 13-2n Six months after implant placement, there is evidence of some recession of the interproximal papillae and the labial soft tissue margins.
Fig 13-2o Six months after implant placement, the sockets are still sealed and interproximal papillae, although slightly reduced, are well represented.

Postoperative management

A periodontal dressing was placed buccal and palatal to the surgical area to prevent food entrapment underneath the pontics and tissue trauma by the tongue. The patient was instructed not to brush the surgical site but to rinse gently with 0.2% chlorhexidine gluconate, and she was prescribed a liquid diet for 2 weeks. After 1 week, some immediately postoperative swelling of the interproximal papillae was noticed (Fig 13-2m).

The sutures were removed, and each month for the next 6 months the pontics were gradually adjusted to maintain their supportive role for the surrounding soft tissues.

Stage 2 implant surgery

Six months following implant placement and socket seal surgery, some resorptive changes of the ridge occurred, with some loss of the interproximal papillae (Figs 13-2n and 13-2o).

To widen the ridge and increase interproximal papillary support, the crestal mucosa was punched out slightly palatal to the center of the implant head (Fig 13-2p), and wide healing abutments were connected.[11] In this way, the original soft tissue profiles were successfully regained (Figs 13-2q and 13-2r).

The healing abutments were seated almost level with the periabutment mucosal margins; thus some reduction of acrylic resin at the basal part of the pontics was necessary to enable complete seating of the transitional restoration. A suggestion to slightly surgically recede the labial soft tissue margins of the central incisor crowns for achieving better esthetic proportions was declined by the patient.

Final transitional restoration

Four weeks following healing abutment connection, the central incisor implants were fitted with anatomically shaped customized gold abutments. The right canine and lateral incisor and left canine and first premolar were fitted with cast-gold posts and cores (Figs 13-2s and 13-2t).

A new transitional restoration was fabricated as follows: The right canine and lateral incisor were fitted with splinted acrylic resin crowns, as were the left canine and first premolar. The abutments at the central incisor sites were fitted with two splinted acrylic resin crowns that had a cantilever pontic for the left lateral incisor site. A 6-month period was allowed for tissue adaptation around the acrylic resin restoration (Fig 13-2u).

Definitive restoration

A silicone soft tissue imitation model enabled the restorative team to fabricate the desired shape, size, character, and emerging profiles of the final metal-ceramic restoration, which was constructed in a similar manner to the previous transitional restoration (Figs 13-2v to 13-2x).

Discussion

The loss of two or more adjacent teeth in the anterior maxilla normally may lead to a marked disfigurement of the alveolar bone crest and its associated underlying mucosa.

In an attempt to reestablish appealing esthetics, the clinician may reconstruct a conventional fixed partial denture with pontics featuring a modified ridge lap design, thereby creating the illusion of a scalloped gingival course with clearly defined interproximal papillae.[44]

In the case of a more severe ridge atrophy, the application of one of the various soft tissue and/or bone augmentation techniques will normally allow the development of functionally stable and esthetically pleasing pontic sites.[45–48]

The pontic area presents an almost "closed system" that is less vulnerable to the destructive factors, such as bacterial infections or mechanical and biophysical changes, that may jeopardize the structural integrity of a relatively "open system" such as an implant-restoration system. However, short-term clinical studies and case reports have demonstrated the ability to develop esthetic soft tissues with distinct interproximal papillae around single-implant restorations.[2,9,11,12,15,16,18–26,30,44,49–53]

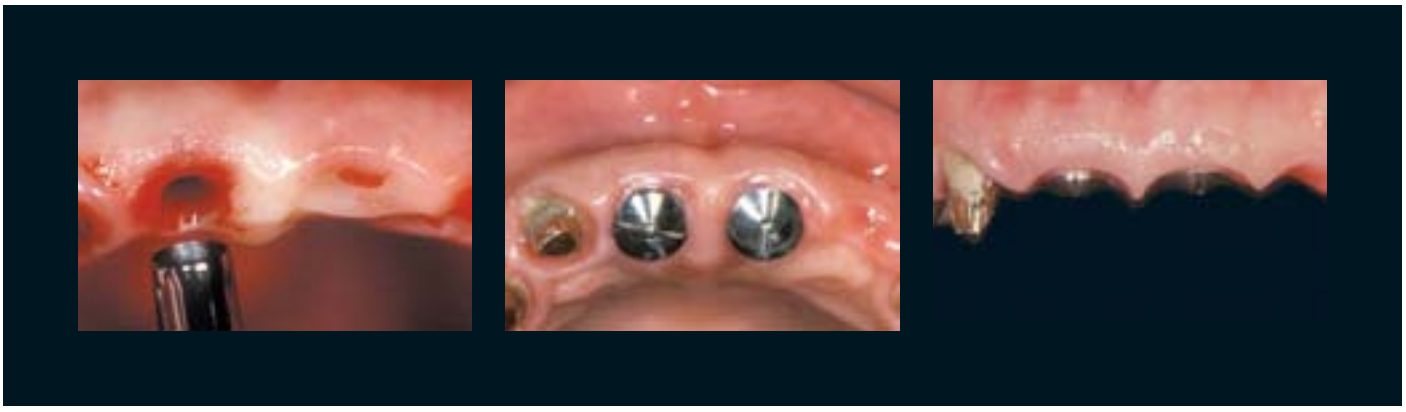


Fig 13-2p A biopsy punch is used to remove a cylindrical portion of soft tissue slightly palatal to the implant head underneath.
Fig 13-2q Wide healing abutments are placed to provide immediate support to the interproximal papillae and the labial soft tissue at the implant sites.
Fig 13-2r Wide healing abutments are shown with preserved interproximal papillae.

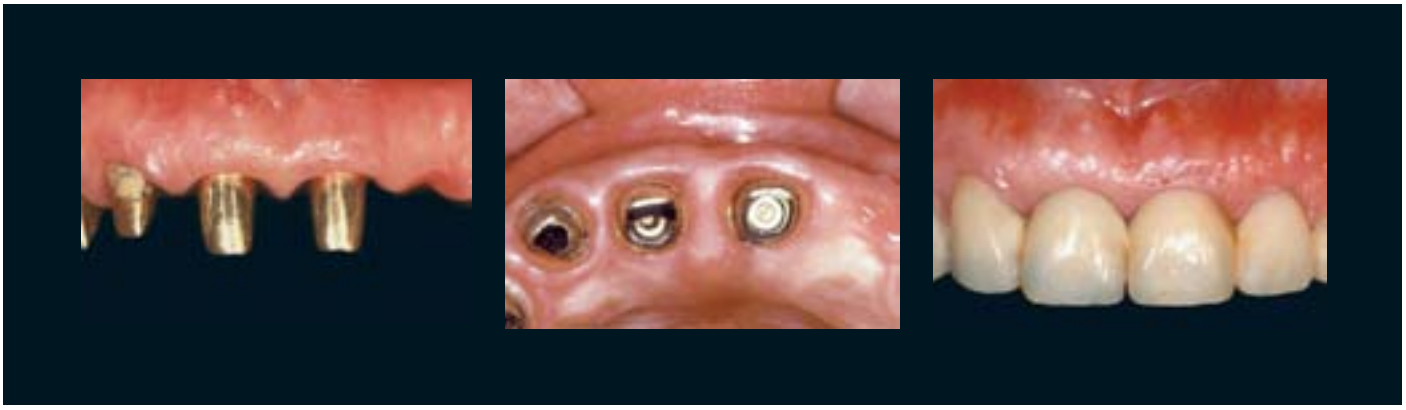
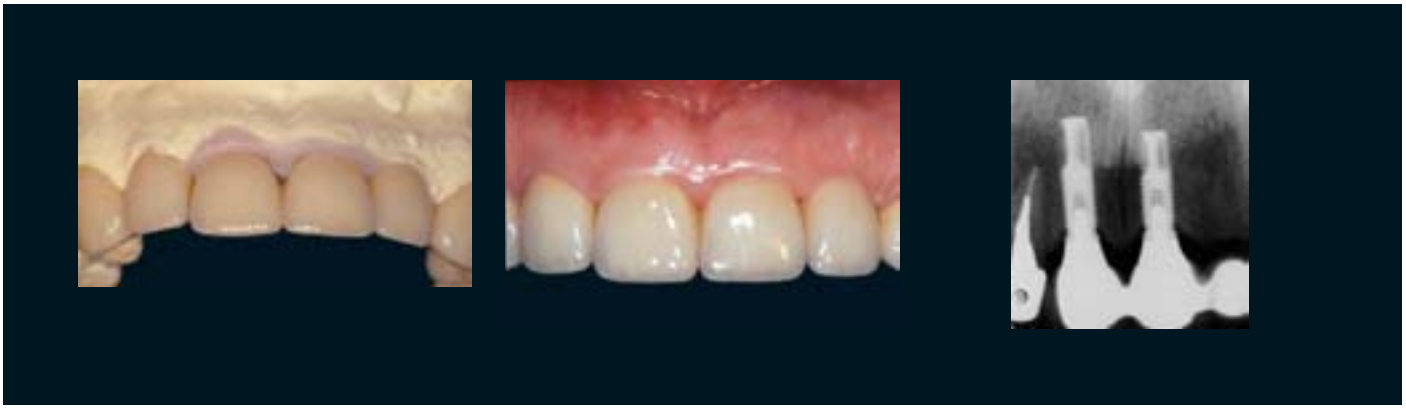


Fig 13-2s Anatomically shaped, customized gold transmucosal abutments are connected to the implants.
Fig 13-2t The occlusal view of the centrally placed transmucosal abutments reveals the well-maintained thickness of the interproximal papillae and labial mucosa.
Fig 13-2u The new provisional fixed partial denture will allow follow-up of potential soft tissue changes.

Fig 13-2v The final porcelain-fused-to-metal restorations are fitted to a silicone soft tissue model.
Fig 13-2w Three years after implant placement, a healthy and esthetic soft tissue configuration is well maintained. (Restorative dentistry by Dr Roni Amid, Tel Aviv, Israel.)
Fig 13-2x Three years after implant placement, solid crestal bone profiles are well maintained.



It is commonly agreed that the presence of a "perfect papilla" between an implant and an adjacent tooth is almost guaranteed when the interproximal bone height is within the normal range.[31–33] However, the re-formation of an interimplant papillary configuration is a far more challenging clinical situation, because current implant designs may not permit the reestablishment of a collagen fiber system like that normally found between adjacent teeth and partially found between a natural tooth and an implant. Thus, support and maintenance of the interimplant papilla may be dependent on the physical rather than the biophysical support gained from the underlying interimplant bone and the approximating artificial crown surfaces as well as on the physical properties of the papilla itself. The belief that there might exist a two-way support between the interimplant bone and the corresponding papilla (ie, that a well-maintained papilla prevents bone resorption) through interconnecting collagen fibers may not be substantiated since no fibers are connected to functional surfaces other than the bone. However, it may be assumed that minor strains transmitted into the bone between adjacent loaded implants may reach the crestal bone peak and stimulate bone remodeling that helps in preventing its resorption. In that view, the clinician should aim to load adjacent implants as early as possible provided anatomic and biologic principles are carefully considered.

The combined surgical and restorative techniques presented in this chapter are implemented immediately after tooth extraction, and their main objective is the preservation and long-term maintenance of the interimplant papillae.

The following are important considerations for maintaining interimplant papillae on a predictable basis when the described treatment modality is used.

Case selection

Periodontal phenotype

A thick, flat gingival phenotype is advantageous for successful implementation of socket seal surgery. Thick, intact gingival margins around the tooth to be extracted are essential for survival of the soft tissue grafted on top of the implant, because initial graft nutrition is dependent mainly on the richly vascularized surrounding socket gingival walls. Thin gingiva may tear easily on extraction and may not maintain the capacity to support the graft.

The ability of this technique to preserve a natural peri-implant soft tissue topography is also highly dependent on the underlying bone levels, facially and interproximally, on the teeth that are being removed as well as on the remaining adjacent dentition. Thus, socket seal surgery, a flapless procedure minimizing postsurgical bone resorption, should be avoided in extraction sockets composed of thin or reduced bony walls that may not provide the needed support for existing and grafted tissues.

Inflammation

Healthy, intact tissues in the surgical field minimize postsurgical inflammatory complications that may result in soft tissue problems such as gingival recession or an increased failure rate of dental implants.[18,49,54] In the presence of long-term or severe periodontal or periapical inflammation, bony dehiscences or fenestrations in the alveolar bony housing may occur, necessitating the use of conventional flap surgery, so that adequate guided bone regenerative procedures may be implemented.

Radiographic evaluation

Radiographs and computed tomograms may reveal the presence of bone topography (such as a deep concave ridge) or bone pathoses (such as extensive periapical defects) that might not be addressed properly by a flapless procedure. Flap elevation in such situations could allow improved inflammation control and the use of barrier membranes for adequate bone regeneration.

Donor site evaluation

The average thickness of the grafted tissue is 2.0 to 2.5 mm. Because no palatal bone should be left exposed, a thick (at least 3.0-mm) donor area in the palatal mucosa is preferred. No palatal rugae should be included in the free graft, because they may reappear in the mature grafted tissue and compromise the esthetic outcome.

Intrasocket implant placement

For functional and esthetic reasons, the implant should be situated palatal to an imaginary line that outlines the curve of the arch formed by the facial surfaces of the adjacent teeth.[55] A space of 1.5 mm between the implant head and the labial bone crest will allow for the lateral component of the biologic width. Placement of the implant too far labially may result in thinner peri-implant tissues

that are positioned apical to the tissues on the adjacent teeth. If the implant is placed too far palatally, the soft tissues may be positioned more incisally than the adjacent tissues, as happens in the natural dentition. In either of these two instances, abutment fabrication and selection become more complicated and function and esthetics are compromised.[30]

To achieve optimal implant positioning, the use of a guiding surgical stent may be helpful. A medium-diameter (usually 4.0 to 4.3 mm) implant is preferred, and the implant head should be located approximately 3 mm apical to the existing labial soft tissue margins.[11,45,53,56] A cut- or thin-headed cover screw may be used to allow adequate space for the soft tissue graft placed atop the implant.

Usually the ridge converges toward the nasal spine; therefore, drilling should be directed slightly palatal to the socket apex to avoid penetration of the buccal mucosa. However, there are situations in which, for anatomic or prosthetic reasons, the drills must be directed in such a way that slight fenestration of the buccal plate may occur. Great care should then be taken not to penetrate but only to lift up the periosteum with the drills and subsequently with the implant itself. The use of tapered drills and implants may successfully prevent the penetration of the labial wall in most cases.

Interimplant distance

Multiple research groups have verified that a biologic width also exists around implants.[57-59] The apical and lateral components of this biologic phenomenon, which are mainly related to micromovements at the implant-abutment interface, cause an unavoidable three-dimensional resorptive pattern around the implant head (at an average distance of 2.0 mm apical and 1.4 mm lateral to from the implant-abutment interface). This led Tarnow et al[38] to propose that two adjacent implants in the esthetic zone be kept at least 3.0 mm apart to avoid a reduction in the interimplant crestal height. However, a distance of 3.0 mm between two implants will allow only a thin peak of bone to exist between them. A thick and wide crestal peak of bone will be better equipped to resist bacterial or biophysical threats and will support the overlying papilla better. For this reason, a minimal distance of 4.0 mm between two implants is preferred (Fig 13-3a). This factor also indicates that adjacent wide-bodied implants may be of limited use in the esthetic zone, because they would diminish the interimplant distance and potentially lead to increased crestal resorption.[38] It further indicates that in most cases where only one of the two neighbor-

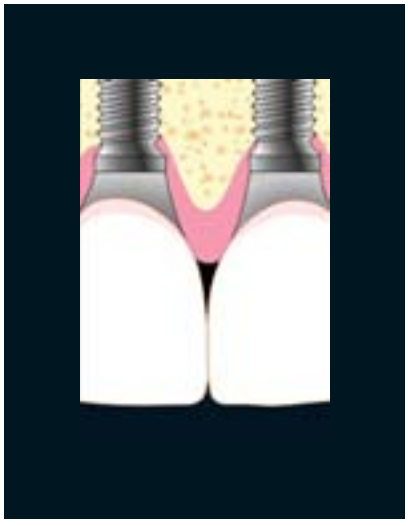
ing implants is in the maxillary lateral incisor position, the interimplant distance will be less than required even if narrow-bodied implants are used. However, even if the original interproximal bone height is successfully maintained, a 1998 and a 2003 article both show that, unlike the interdental papilla, the supracrestal height of the interimplant papilla may rarely exceed 3.0 mm.[33,60] Therefore, typical adjacent implant-supported crowns have their contact area lengthened 2.0 mm or more to meet the reduced papilla (Fig 13-3b).

Socket sealing with soft tissue graft

The advantage of utilizing barrier membranes to promote bone regeneration around exposed implant surfaces is well documented.[61–67] Complete bone regeneration around an implant placed in a fresh, intact extraction socket may be clinically expected without the use of a membrane, provided that the healing socket is fully protected by the mucosal flap,[13,68–71] or a free mucosal graft.[11,39,72]

However, the width of the gap between implant surface and the bony walls at the time of implant placement has a significant impact on the histologic percentage and the height of bone-to-implant contact.[68,70,73–76] Namely, as the initial gap increases, the amount of bone-to-implant contact diminishes and the highest point of bone-to-implant contact moves apically.

Further disturbance in the healing process may occur if the socket orifice is only anatomically sealed with prosthetic parts but remains (biologically) open, as demonstrated in immediate implant and immediate restoration cases.[77–80]



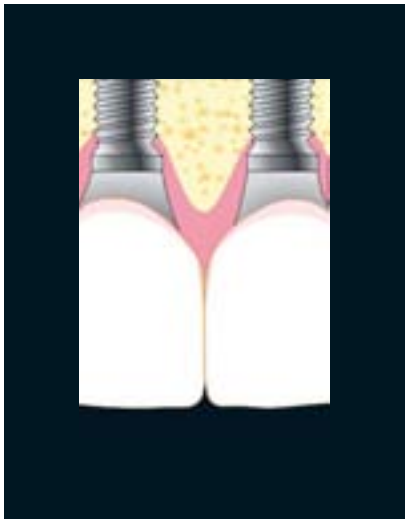
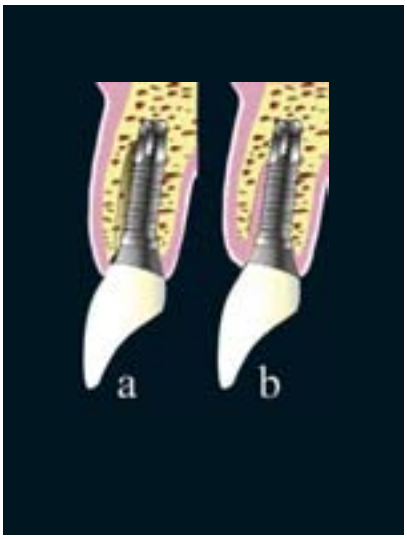


Fig 13-3a A minimum distance of 4.0 mm between the implants is necessary to prevent crestal bone resorption and establish a broad-based, well-supported interimplant papilla.
Fig 13-3b To seal the "black triangle," the contact area is lengthened 2.0 mm or more to meet the peak of the papilla.



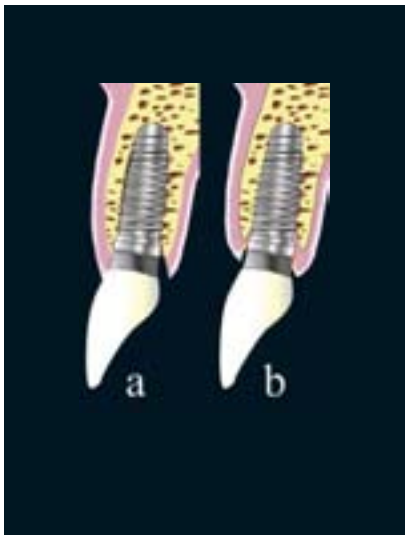


Fig 13-4 *(a)* Immediate implant placement and loading may not provide sufficient isolation of the healing socket from chemical or bacteriologic threats. *(b)* Soft tissue ingrowth in the socket may interfere with the process of osseointegration. Marginal soft tissue recession is likely to occur.
Fig 13-5 *(a)* A wide-bodied implant may exert pressure on the labial plate. *(b)* Marginal bone and soft tissue recession will follow, and prosthetic parts will be exposed.

Indeed, failure to provide complete and secure isolation of the socket during the healing phase exposes the implant and the surrounding organizing tissues within the socket to bacterial, mechanical, and chemical disturbances. Moreover, epithelial and connective tissue cells may rapidly repopulate the naturally occurring gap between implant surfaces and the surrounding bony walls; these undesired cells will further prevent osteoprogenitor cells from reaching the implant surfaces and will subsequently reduce the quantity and quality of osseointegration. Finally, the relatively thin marginal soft tissue is likely to recede, resulting in an unpleasant, elongated clinical crown (Fig 13-4).

Wide-bodied implants have been produced to fit the socket walls in an attempt to prevent this undesired cell population from interfering with the osseointegration process. However, the immediate close contact of implant surfaces with thin cortical plates, especially the labial plate, might result in partial or even complete disappearance of the plate. This in turn might be followed by marginal soft tissue recession (Fig 13-5).

In socket seal surgery (Fig 13-6), the soft tissue grafted atop the implant cover screw becomes biologically integrated with the surrounding soft tissue walls and prevents epithelial proliferation and downgrowth inside the socket. It may also be assumed that the connective tissue cells within the soft tissue graft are "too busy staying alive" and therefore are not potent enough in the critical initial healing stages to multiply and penetrate the organizing clot underneath. A similar biologic mechanism, namely retardation of epithelial and connective tissue via free gingival graft, was previously suggested in

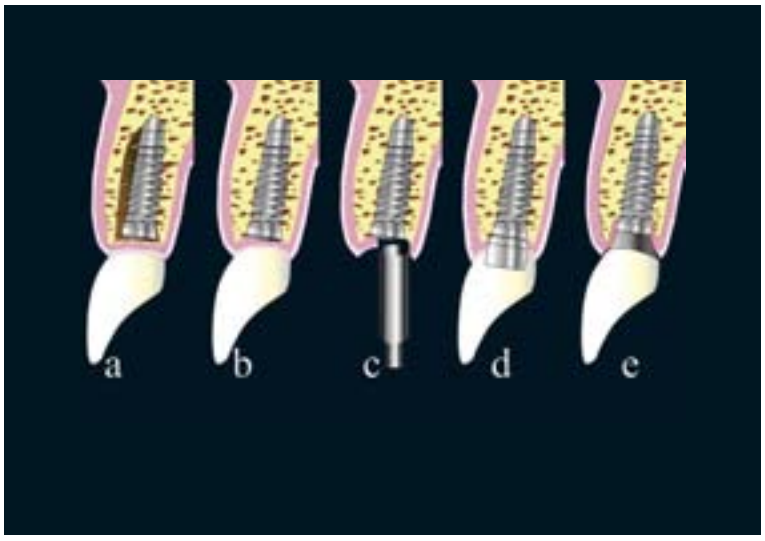


Fig 13-6 *(a)* The soft tissue graft is seated atop the implant head and underneath the pontic. *(b)* The soft tissue graft is integrated with the socket soft tissue walls while the bone matures around the implant. *(c)* A biopsy punch may be directed slightly palatal to the implant axis, partially exposing the implant head and leaving thick labial soft tissue margins. *(d)* The thick soft tissue on the labial aspect of the crest is pushed further labially during placement of the healing abutment. *(e)* The final outcome typically is development of the biologic width around the implant head and preservation of soft tissue height and width for an optimal esthetic outcome.

periodontal regenerative procedures.[81] Moreover, the thin, fatty submucosal layer often included in the graft may act as a physiologic barrier against undesired cell penetration of the organizing clot within the socket. A commercial barrier membrane might provide superior protection against undesirable cell penetration into the socket but would at the same time necessitate complex flap manipulation; wound sterility and esthetic outcome may be compromised and crestal bone resorption is at risk if the barrier becomes exposed.[61,82,83] Furthermore, in addition to its wound-protective capacity, the grafted soft tissue also augments the quality and quantity of soft tissues around the implant to be exposed at the second stage, thereby enhancing the clinician's ability to design and sculpt the desired soft tissue contours around the implant restoration.[11,13] Advantages of socket seal surgery over other available techniques are summarized in Boxes 13-1 and 13-2.

Prosthetic soft tissue contouring and support

While the presence of osseous scallop morphology alone establishes a degree of papillary form, it would not account for the entire presence of the papillary height.[41]

Critical to the preservation of the height of this tissue following extraction is the immediate support gained from the approximating restorative surfaces. The provisional restoration should be fabricated with the same embrasure volume that existed prior to extraction; the papilla is subsequently permitted to re-form. If the height of the papilla was lost following extraction, however, it can, in rare cases, be recreated with pressure.[41] When socket seal surgery is utilized, to avoid

undesired pressure on the soft tissue grafts that would jeopardize their vitality, the provisional pontics should be only minimally subgingivally placed. Thus, facial and interproximal gingival margin support is ultimately derived not just from the provisional pontics but also, mainly, from the soft tissue grafts.[33,60]

Abutment shoulder location and emergence profile

Anatomically oriented, the abutment shoulder should follow the scalloped course of the peri-implant mucosa at a distance that ensures easy removal of excess cement and permits efficient use of oral hygiene measures such as Superfloss (Oral-B, Boston, MA).[16] Interproximally, however, care should be taken to minimize the emergence angle of the abutments so that at least a 3 mm gap remains between the abutments at the abutment-crown interface level. This gap is mandatory for establishing a broad-based, well-supported, and vascularized interimplant papilla for a long-term result.

Box 13-1

Advantages of socket seal surgery combined with flapless implant placement over regenerative flap procedures using commercial membranes

1. The implant may be ideally located because the soft tissue orifice of the socket dictates the exact desired position of the implant head.
2. Bacterial contamination may be more efficiently prevented because the surgical site is minimally exposed to the oral cavity.
3. There is no loss of keratinized gingiva at the buccal aspect of the implant site and the adjacent teeth.
4. Only negligible loss of interdental papillary height may occur.
5. There is no recession of the marginal gingiva at the adjacent teeth.
6. No scarring of the labial mucosa occurs.
7. Vestibular depth is not reduced.
8. Postoperative swelling and pain are minimal.
9. Second-stage surgery involves no or only minimal flap retraction and is not associated with any untoward effects (no need for surgical membrane removal).
10. The procedure is significantly less time consuming.
11. The treatment period from tooth extraction to implant loading is significantly reduced.
12. The procedure is less expensive (no need for a synthetic membrane).

Box 13-2

Advantages of socket seal surgery combined with flapless immediate implant placement over flapless immediate implant placement with immediate loading

1. Osseointegration is improved by protection against mechanical, chemical, and bacterial invasion and better clot stabilization.
2. Soft tissue recession is minimized by enhancing the width of the labial margins and the interproximal papillae.

Future developments for perfect interimplant papillae

Currently it is a fact that contemporary implant systems do not offer the same configuration and surface characteristics as natural dentition. The inability of connective tissue fibers to insert into implant surfaces dictates the inferiority of the "implant zone of connective tissue contact"[59] compared with the natural dental connective tissue attachment and its ability to resist infection and support and maintain the configuration, texture, and color of the periodontal and gingival tissues. Specifically, the interimplant papillary configuration relies mainly on crestal bone and the overlying soft tissue volume rather than on solid supracrestal functional connective tissue fiber attachments (Figs 13-7a and 13-7b).

Only recently a new "parabolic"[84] or "scalloped"[85] implant design (ie, a scalloped cementoenamel junction–like configuration) has been proposed for use. This implant design would stretch both the roughened surface texture and the problematic microgap coronally to the maximum level possible. Further coronal displacement of the three-dimensional biologic width would follow, paving the way for optimal

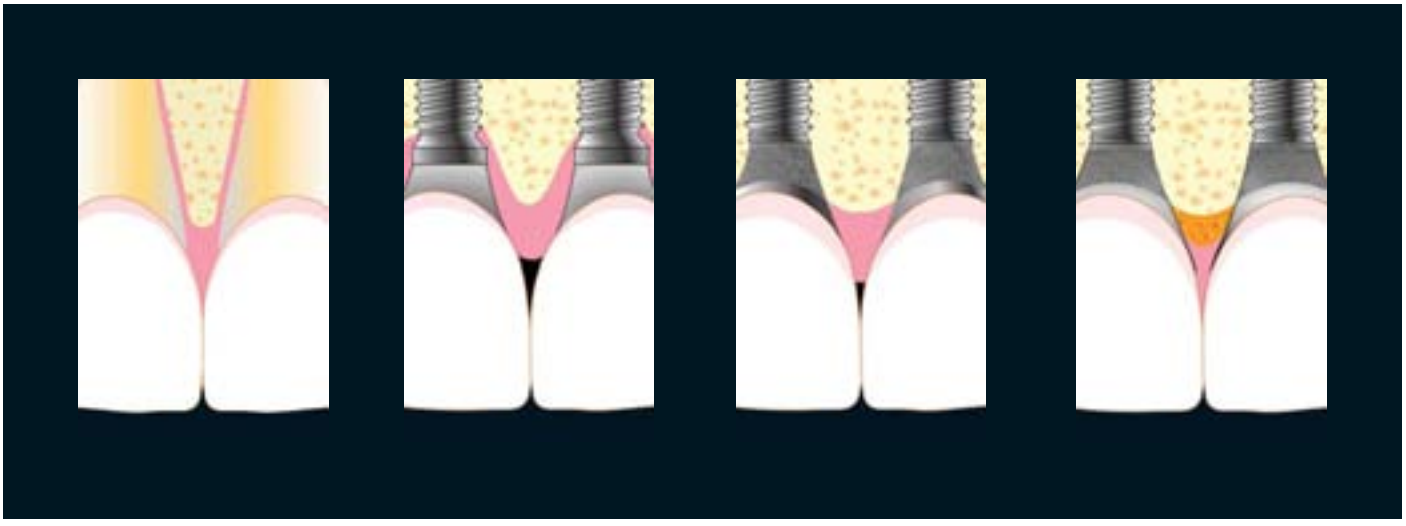


Fig 13-7a Adjacent teeth with normal periodontium may support a normal interdental papilla height (approximately 5 mm).
Fig 13-7b Adjacent flat-headed implants may maintain interproximal bone height but may support only a reduced interimplant papilla height (approximately 3 mm).
Fig 13-7c Adjacent scalloped implants placed immediately postextraction will likely allow a broader interimplant bone with a greater than normal papilla height (approximately 4 mm).
Fig 13-7d Adjacent scalloped implants placed in vertically and horizontally augmented ridge with supranatural crestal bone height (orange) will support a 3- to 4-mm interimplant papilla height with a complete closure of the so-called black triangle.

preservation of existing crestal bone. By this means a broader bony base rather than just a tiny peak would remain, providing improved support for a more coronal papillary configuration (Fig 13-7c).

It may further be assumed that vertical and horizontal ridge augmentation with formation of supranatural interproximal bone would provide the physical capacity to support a perfectly designed papilla (Fig 13-7d). The ideal interimplant papilla would thus obtain its main support from a more coronally located, broad-based crestal bone and would not have to rely on increased soft tissue volume that might prove physically and biologically inferior in its long-term stability.

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