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Implants in the Esthetic Zone

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The introduction of osseointegration by Brånemark and coworkers [1,2] and replacement of lost teeth by implants have revolutionized oral rehabilitation while significantly advancing restorative dentistry. Implant-supported restorations in edentulous or partially edentulous patients have been shown to be highly predictable in numerous studies [3–8]. In the early years of modern implantology, the chief concern was tissue health and implant survival. Over the last decade, there has been an increasing appreciation that esthetics is just as important to the success of the final restoration as health. Indeed, it can be said to represent a different aspect of health. The World Health Organization has defined health as a state of "complete physical, mental, and social well-being, and not merely the absence of disease and infirmity." Patients increasingly demand restorations that are as esthetic as they are functional. Unlike implants in the early years of osseointegration, many of the implants now being placed are in the anterior maxillary region and other esthetically sensitive areas.

Consequently, many recent studies have concentrated on treatment outcomes of implant therapy performed in the esthetic zone [9–13]. In a review of the recent literature, Belser and colleagues reported that dental implants in the anterior maxilla have an overall survival and success rate similar to those reported for other segments of the jaw [14]. In an 11-year retrospective study, Eckert and Wollen evaluated 1170 implants placed in partially edentulous patients and found no differences in survival rates of the implants with regard to their anatomical location [15]. In a 5-year multicenter study, Henry and colleagues reported an implant success rate of about 96% for single-tooth replacements in the anterior maxilla. However, they also reported an esthetic failure rate of about 9% for implant placement in this area [4]. This underscores the critical importance of esthetics as a determinant of implant success and patient satisfaction.

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Implant placement and restoration to replace single or multiple teeth in the esthetic zone is an especially challenging area for the clinician, particularly in sites with multiple missing teeth and with deficiencies in soft tissue or bone. Preservation or creation of a soft tissue scaffold needed to create the illusion of a natural tooth is often challenging and difficult to achieve [16,17]. Placement of a dental implant in the esthetic zone is a technique-sensitive procedure with little room for error. A subtle mistake in the positioning of the implant or the mishandling of soft or hard tissue can lead to esthetic failure and patient dissatisfaction [14,18,19]. This article presents guidelines for ideal implant positioning and for a variety of therapeutic modalities that can be implemented for addressing different clinical situations involving replacement of missing teeth in the esthetic zone.

Diagnosis and treatment planning

To achieve a successful esthetic result, implant placement in the esthetic zone demands thorough preoperative diagnosis and treatment planning combined with excellent clinical skills. Preoperative assessment of the patient's expectations is also of paramount importance. If the patient is found to have unrealistic expectations, a careful explanation might be necessary to clarify what the patient should expect. The skills of the entire implant team, consisting of the restorative dentist, implant surgeon, and dental technician, are all required to develop and execute a comprehensive, well-sequenced treatment plan. Such teamwork is indispensable to achieve a superior result.

Data collection

The development of a proper treatment plan requires accurate and comprehensive data collection. The database must include the patient's chief complaint, comprehensive medical history, dental history, results of extra-oral and intra-oral clinical examinations, radiographic examination results, documentation of patient expectations, and an assessment of risk factors for implant failure (esthetic or functional) [20]. Uncontrolled medical conditions; parafunctional habits, such as bruxism; poor compliance with oral hygiene or maintenance regimens; active periodontal disease; and smoking status should be evaluated and taken into consideration.

For ideal implant placement and optimal esthetic restorations, a comprehensive evaluation of the edentulous site must be performed [18]. Facial, dental, and periodontal status must be evaluated. A facial evaluation provides general esthetic parameters, such as orientation of occlusal plane, lip support, symmetry, gingival scaffold, and smile line. A dental evaluation provides information about the edentulous site in three dimensions, as well as information about occlusion, adjacent teeth, interarch relationships

and presence of diastemata. Finally, a comprehensive periodontal examination, including home care assessment, periodontal charting, and radiographic analysis, are essential for an optimal functional and esthetic result [21].

Gingival recession and biotypes

The gingival biotype should be assessed because such an assessment will partly determine the risk for postsurgical recession [22,23]. A thin, highly scalloped gingival biotype is much less resistant to trauma from surgical or restorative procedures and, consequently, is more prone to recession in comparison with a thick, flat gingival biotype. A thin gingival biotype dictates placement of the implant in a slightly more palatal position to reduce the chance of recession and prevent a titanium "shadow" from showing through the thin gingival tissue. Similarly, the implant should be placed somewhat more apically to achieve a proper emergence profile and avoid a ridge lap restoration [18].

Because patients with minimal gingival thickness are at higher risk of esthetic failure, it may sometimes be prudent to recommend soft tissue augmentation or conventional prosthetic prosthesis rather than implant placement. At the very least, such patients should be informed of the possibility of postoperative recession and the esthetic consequences. Kan and colleagues reported that peri-implant mucosal dimensions were greater in patients with a thick gingival biotype than those with a thin biotype [24]. The long-term stability of esthetic soft tissue around an implant restoration depends largely on the presence of adequate soft tissue volume in a vertical and buccolingual direction [25]. An adequate volume of soft tissue provides a good emergence profile of the implant restoration and serves to mask the underlying metal implant, especially when combined with suitably apical placement. A subepithelial connective tissue graft may be considered to augment soft tissue volume when insufficient tissue volume is present [26]. More rigorous studies are needed to determine the actual risk factors for postimplant recession and its treatment.

Interdental papilla

The supporting bone influences the establishment of overlying soft tissue compartments and the bone quality and quantity must be carefully assessed [21,27]. The vertical bone height in the interproximal sites, as well as the horizontal thickness and vertical height of the buccal bone wall in the edentulous site, are important determinants of esthetic success [19,24,27–31]. The bone crest should be within a physiological distance of 2 to 3 mm of the cemento-enamel junction or, when recession is present, 2 to 3 mm of the buccal gingival margin (Fig. 1).

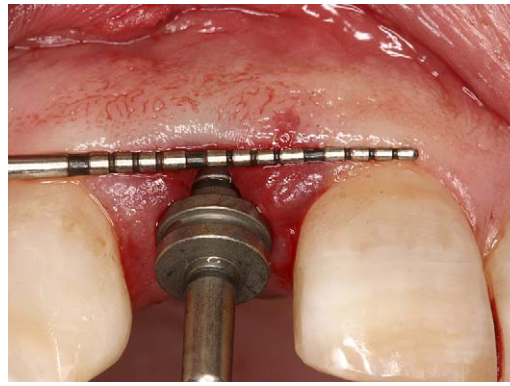

Fig. 1. Apicocoronal position of implant. Implant platform should be within 2 to 3 mm apical to the mid-buccal gingival margin.

The distance between the underlying interproximal bone height on the adjacent natural teeth and the final prosthetic contact point dictates the formation and spontaneous regeneration of the interdental papillae associated with the implant. If this distance is more than 5 mm, the complete papilla formation will be compromised. This often leads to the so-called ''blank triangle'' [32,33]. This effect may differ according to whether the implant is adjacent to another implant or a natural tooth. For example, Kan and colleagues reported that the height of the interproximal papilla of the crown is independent of the proximal bone level next to the implant, but is related to the interproximal bone height of the neighboring teeth [24].

Tarnow and colleagues found that, in most cases, the vertical distance from the crest of bone to the height of the interproximal papilla between adjacent implants is 2 to 4 mm [31]. Papillary height can, therefore, be partially influenced by spacing of the implants and placement of the contact point. It is also likely that emergence profile and interproximal restoration contours may also play a role in papillary form, but these determinants are more difficult to study and no good evidence supports specific recommendations.

A diagnostic wax-up is often required, especially in cases involving placement of multiple implants. The wax-up previews the future restoration and potential difficulties and can be used to educate the patient during the informed consent process. A duplicate cast can be fabricated from an impression of the wax-up and be used to create a surgical template, which serves as a guide to the surgeon during implant placement. The entire treatment plan should be developed with input from the entire implant team.

Following the development of a proper treatment plan, the plan is presented to the patient and thoroughly discussed, along with a consideration of the risks, benefits, and alternative forms of therapy. Informed consent

is obtained and the patient's expectations are again determined. Only after this discussion can surgery be undertaken.

Implant placement

The surgical approach must be carefully planned and executed. Tischler has proposed guidelines for implant placement and restoration in the esthetic zone [34]. According to these guidelines, the surgeon should:

- Employ a conservative flap design;
- Evaluate the existing bone and soft tissue;
- Time the placement correctly;
- Visualize the three-dimensional position of the implant;
- Consider healing time before implant loading;
- Consider the determinants of emergence profile; and
- Select a proper abutment and final restoration design.

The implant should be considered the apical extension of the restoration and the preferred design of the restoration should guide the surgical placement of the implant [27,35]. This concept is known as restoration-driven implant placement, in contrast to the previously accepted concept of bone-driven implant placement. Restoration-driven implant placement mandates that the implant is placed where it can be properly restored. If the desired site is lacking in bone or soft tissue, then augmentation procedures must be employed to create an acceptable site. Optimal esthetic implant restoration depends on proper three-dimensional implant positioning [36]. Four positional parameters contribute to the success of the restoration and all must be carefully considered during implant placement. These are the buccolingual, mesiodistal, and apicocoronal positions relative to the implant platform, as well as the angulation of the implant. Prosthetic design factors (eg, cement- versus screw-retained prosthesis) are also critical.

Buccolingual position

An implant placed too far buccally often results in a dehiscence of the buccal cortical plate and has a high potential for gingival recession. In addition, this placement vastly complicates the restoration of the implant. On the other hand, an implant placed too far to the palatal often requires a ridge-lap restoration that is both unhygienic and unesthetic [13,18,37]. Proper buccolingual positioning of the implant simplifies the restorative procedure, results in a proper emergence profile, and facilitates oral hygiene. The buccal wall must maintain a thickness of at least 1 mm to prevent recession and improve esthetics. In his study of over 3000 implants, Spray measured the vertical dimension of facial bone between implant placement and

uncovering stage, comparing these changes to facial bone thickness. As the bone thickness approached 1.8 to 2 mm, bone loss decreased significantly and some evidence of bone gain was seen [38].

The ideal buccal-lingual position is a function of the desired crown location and the design of the implant and abutment. Placement should be such that the crown emerges naturally from the soft tissue scaffold to create the illusion of a natural tooth [39]. To achieve this, the centerline of the implant must often be located at or near the center of the tooth it replaces [40]. The implant must be positioned in such a way that the buccal aspect of the implant platform just touches an imaginary line that touches the incisal edges of the adjacent teeth (Fig. 2). There are, however, situations requiring that the implant be placed in a more palatal position (eg, in patients presenting with a thin gingival biotype [18]). Conversely, it is sometimes wiser to place the implant in slight labioversion. Occlusal considerations occasionally necessitate such placement, particularly in cases involving excessive vertical overlap [18,27].

Mesiodistal position

To avoid an unfavorable esthetic outcome, the available mesiodistal space must be carefully measured so that an implant of the proper size may be selected and proper implant spacing planned. Placement of an implant too close to adjacent implants or teeth may result in interproximal bone loss with subsequent loss of papillary height. Studies have shown that, in addition to the vertical component, there is a lateral component to the crestal bone loss around the implant [29,41]. Based on these findings, a minimum distance of 1.5 to 2 mm should be maintained between implants and neighboring teeth and, in the case of multiple implants, a space of 3 to 4 mm at the implant abutment level should be maintained between implants [29,41]. A strong inverse correlation exists between crestal bone loss at adjacent teeth or between implants and the horizontal distance of the implant fixture to the tooth or

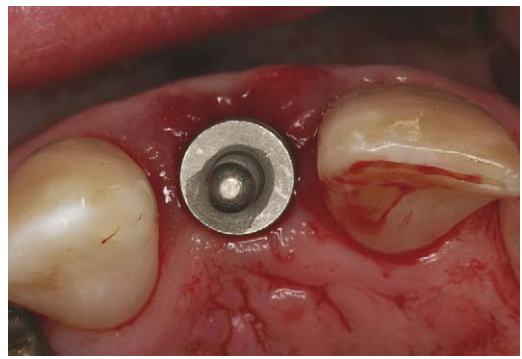

Fig. 2. Buccolingual position of implant. Buccal aspect of the implant platform touches an imaginary line that touches the incisal edges of the adjacent teeth.

implant [29,41]. In the case of a maxillary central incisor site, it may be desirable to place the implant slightly to the distal to mimic the natural asymmetry of the gingival contour often seen in these teeth.

Apicocoronal position or countersink

Apical positioning of the implant is required to mask the metal of the implant and abutment. This positioning may involve countersinking the osteotomy site. The degree to which this is done and the manner in which it is accomplished will depend, in part, on the design of the implant head. The amount of countersinking required is somewhat dependent upon the implant diameter [22]. The wider the implant, the less distance is needed to form a gradual emergence profile. In such cases, less countersinking will be required. The distance from the platform to the mucosal margin is sometimes referred to as ''running room.'' The countersink should provide sufficient running room to form a gradual transition between the implant platform and the contour of the restoration (ie, emergence profile). A variable amount of running room is needed to compensate for an implant platform that often has a smaller diameter than that of the cervix of the tooth it replaces. Without apical placement to compensate for the difference in diameter, the transition from implant to tooth can be abrupt.

In general, the more apical the placement of the implant, the better the emergence profile [42]. However, locating the implant-abutment interface more apically means losing more crestal bone for establishing the periimplant biological width [43–45]. It is generally accepted that the crestal bone is reestablished 1.5 mm apical to the implant-abutment interface. This spacing is also known as the microgap. The apicocoronal position of the implant should provide a balance between health and esthetics. The emergence profile and the location of the microgap are the two most important parameters affecting health and esthetics. Generally speaking, there is an inverse relationship between these two parameters. The more apical the implant placement, the more esthetic the restoration (and the less healthy the tissue). Excessive countersinking of the implant can cause saucerization, which is the undesirable circumferential vertical and horizontal crestal bone loss, and subsequent gingival recession after loading. Conversely, superficial placement of the implant can lead to visible metal margin or optical reflection and a compromised restoration without a gradual, pleasing emergence profile [46].

In a patient without gingival recession, it is generally acceptable to use the cemento-enamel junction (CEJ) location of adjacent teeth as a point of reference to determine the apicocoronal position of the implant platform. The sink depth of the implant shoulder should be 1 to 2 mm for a one-stage implant or 2 to 3 mm for a two-stage implant apically to the imaginary line connecting mid-buccal of CEJs of the adjacent teeth without gingival recession. It is essential to take into consideration the varying CEJs of the

adjacent teeth. For example, the CEJ of the maxillary lateral incisor is usually located 1 mm more coronally than the CEJs of the adjacent central incisor and canine. In patients with gingival recession, the mid-buccal gingival margin can be used as a reference in lieu of the CEJ.

A final consideration involves the potential for additional growth of the maxilla. It has been suggested that implants should be placed only after the age of 15 in females and 18 in males [47] to avoid potential problems caused by further skeletal growth. However, some evidence shows continuous vertical growth of the maxilla after age 18 [48,49], so the issue is not entirely resolved.

Implant angulation

Ideally, implants should be placed so that the abutment resembles the preparation of a natural tooth. In screw-retained prostheses, poor angulation can alter screw placement, which may have a significant effect on esthetics [46]. Implants positioned with too much angulation either toward the palatal or the buccal often compromise esthetics and may also impact home care [42]. It is generally accepted that the implant angulation should mimic the angulation of adjacent teeth if the teeth are in reasonably good alignment. Most implant systems include a provision for some type of angled or custom abutments to compensate for situations where ideal alignment may not be possible. Surgical guides can help provide the right angulation, as this may be difficult to visualize at the time of surgery. In the maxillary anterior regions, a subtle palatal angulation is sometimes recommended to increase labial soft tissue bulk and to avoid the problems with thin buccal walls described earlier [34].

Timing of implant placement following tooth removal

Garber has described three scenarios for the timing of implant placement following extraction [27]. Immediate placement occurs at the time of tooth extraction, staged placement occurs at least 8 weeks following extraction, and delayed placement is performed 3 months or more following extraction. A simplified scheme, presented below, considers only two groups—implants placed immediately following extraction and those placed a variable time following tooth removal.

Immediate placement of implant at the time of extraction

Following tooth removal, a variable amount of ridge collapse takes place because of bone resorption. This bone loss can occur in either buccal-lingual or apicocoronal dimensions or in both [50–52]. As much as 3 to 4 mm of buccolingual and apicocoronal bone resorption can occur during the 6 months following extraction. This bone resorption reduces bone available

for implant placement and may preclude such treatment altogether. To correct these defects, complex regenerative procedures are sometimes required. Unfortunately, these procedures involve additional treatment time, morbidity, and cost.

To avoid these problems, a technique has been introduced involving simultaneous tooth extraction and immediate implant placement [39]. This technique allows for bone and soft tissue preservation and shortens treatment time. Placing implants immediately or soon after extraction preserves bone and overlying soft tissue, according to clinical observations [28,53]. The necessary initial implant stability is obtained through the use of longer and wider implants, which are capable of engaging bone in the apical and palatal portions of the socket. Several studies have shown the success rates of immediate implants to be comparable to those placed in healed extraction sites [54–56]. Since the hard and soft tissue scaffolds can be maintained by immediate implant placement, it is appropriate to consider this option in the esthetic zone. However, because of poor planning and surgical misadventure, compromised esthetic results are sometimes observed following immediate placement.

Atraumatic extraction

After clinical and radiographic evaluation, the hopeless tooth is atraumatically extracted so as to preserve both the bony socket wall and soft tissue architecture. A number of instruments have been developed for this purpose, including the periotome [57,58]. The periotome, a slim elevator-like instrument, is introduced into the periodontal ligament space and used to sever the periodontal ligament. The instrument is gradually advanced toward the apex of the tooth. Care should be taken to preserve the thin buccal wall of maxillary incisors. When necessary to preserve the integrity of the socket, the tooth is carefully sectioned and the fragments carefully removed [59]. Whenever possible, the surgeon should avoid reflecting a flap to preserve the vascular supply and periosteum covering the bone (Fig. 3). This will minimize bone resorption [60]. Once the extraction is completed, the socket is debrided and then evaluated.

Implant placement

The decision regarding immediate implant placement is determined by three factors:

- Absence of acute noncontained infection;
- Achievement of initial stability of the implant; and
- Sufficient quantity and quality of bone present.

In the presence of disseminated infection in an extraction socket, delaying placement for about 3 weeks postextraction may be considered to allow for resolution of local pathology and achievement of primary soft tissue closure [34]. The integrity of the socket is evaluated. If the socket wall is intact and

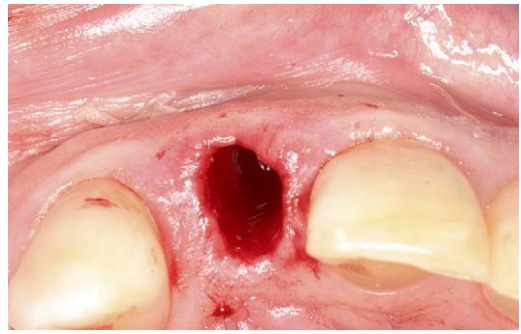

Fig. 3. Atraumatic tooth extraction. Avoidance of flap reflection preserves the vascular supply.

a favorable horizontal and vertical level of both soft tissue and bone architecture is present, immediate implant placement may be attempted. The necessary initial implant stability is obtained through the apical and palatal engagement of existing bone of the maxillary socket by using a long implant. Tapered implants or implants with wider diameters can also be of use in engaging the bony walls.

The three-dimensional placement of the implant is visualized and planned using the surgical guide. It is often helpful to gauge the dimensions of the socket relative to implant configuration by placing various depth gauges in the socket. Some minimum amount of apical stability is required. Unfortunately, evidence is insufficient to give clear guidelines, but in our clinic we must be able to engage at least 6 mm of bone of reasonable quality before considering immediate placement. The depth gauge helps us make that assessment. A minimum of 1 mm of buccal plate should be maintained to enhance long-term prognosis and reduce the risk of soft tissue recession. A concomitant soft tissue augmentation at the same time of implant placement may be recommended in patients with a thin gingival biotype to further reduce the risk of soft tissue recession and buccal bone resorption.

After an immediate implant placement into extraction socket, it is critical to assess the horizontal space, if any, from the implant surface to the socket wall. Studies have shown that no bone augmentation is needed if the peri-implant space is 2 mm or less because spontaneous bone fill and osseointegration will take place when using a rough surface implant [61–63]. In sites where the peri-implant horizontal defect measures more than 2 mm, a bone regenerating technique is required to predictably achieve bone fill and increase the percentage of bone-to-implant contact [61].

When a slight horizontal defect in the socket buccal wall is present, the size of this defect should be determined. If this defect is less than 5 mm in the apicocoronal direction [64] or less than one third of the mesiodistal dimension between the adjacent teeth [65], immediate implant placement

at the time of extraction can be accomplished. Depending on the size of the dehiscence, lateral bone augmentation [65] or guided bone regeneration may be performed as needed [66–68].

In the case of larger bony defects, more extensive augmentation is required. Generally, if sufficient initial stability of the implant can be obtained, a bone grafting procedure with membrane can usually be performed at the time of placement [69–75]. In the case of bony defects so extensive that implant placement is precluded, then delayed implant placement following lateral ridge augmentation is indicated. Grafting materials used for this purpose include both autogenous bone [76–78] or allograft bone replacement grafts [72,79].

Vertical (apicocoronal) bone loss is usually the result of periodontal disease and represents a particularly difficult challenge. No surgical approach is available to predictably augment the ridge height. Some case reports suggest a surgical approach using nonresorbable membrane [80,81], while others suggest using a submerged implant to maintain space under a barrier membrane [82,83]. A nonsurgical approach, orthodontic extrusion, has been introduced to increase the volume of the bone and the height of the soft tissue [64]. The tooth is gradually and slowly extruded by orthodontic forces, bringing with it bone and soft tissue. At the end of tooth movement, the tooth is removed and an implant placed. Obviously, this technique is time-consuming and does not address the problem of mature edentulous sites that require additional vertical bone height. Some investigators report good success with distraction osteogenesis, but that discussion is beyond the scope of this paper. For further information on this modality, the reader should refer to recent reviews [84,85].

Implant placement in edentulous sites

When an edentulous site in the esthetic zone is planned for implant placement, the site must be thoroughly evaluated. Garber has proposed a classification for such sites [86]. This classification depends on the type of reconstruction needed to get good positioning of the implant.

Garber Class I

When favorable horizontal and vertical levels of both soft tissue and bone are present, ideal implant positioning is a straightforward procedure. A concomitant soft tissue augmentation at the same time of implant placement is preferred in patients with a thin gingival biotype to prevent the risk of soft tissue recession and buccal bone resorption.

Garber Class II

Sites with no vertical bone loss and slight horizontal bone deficiency measuring about 1 to 2 mm narrower than normal can be expanded by using serial osteotomes instead of drilling, according to the method described by

Summers [87]. This technique will permit slight expansion of the bony ridge horizontally while simultaneously compressing the maxillary cancellous bone to improve the bone quality. However, this technique has not been investigated and insufficient evidence exists to make evidence-based recommendations. As always, one alternative is to get sufficient initial stability of the implant and lateral augmentation of the ridge using bone grafting techniques [69–71] or bone generation techniques [69,71–75].

Garber Class III

For sites with no vertical bone loss and horizontal bone loss greater than Class II, implant placement can be attempted, provided an initial stability is achieved. Guided bone regeneration is necessary.

Garber Class IV

In sites with no vertical bone loss but significant horizontal loss, it is necessary to use a staged approach in which the ridge is widened with guided bone regeneration. Implants are later placed after a suitable healing period of several months [76–79], using block bone grafts or guided bone regeneration techniques [69,72]. Autogenous bone has generally been the graft material of choice in these procedures.

Garber Class V

Sites with extensive apicocoronal bone loss present a significant challenge to the surgeon. As noted above, there are no well-documented surgical approaches available to predictably augment bony ridge height. Some case reports suggest a surgical approach of guided bone regeneration using a nonresorbable membrane and delayed implant placement [80,81], while other investigators suggest tenting barrier membranes with an immediately placed, submerged implant as a space-making device under the membrane [82,83]. Distraction osteogenesis has been used to augment the ridge height, but no long-term clinical data is available on outcomes in this application [88–90].

Regardless of the type of procedure planned for the mature site, proper flap management is critical for success. Careful attention should be paid to incision design and flap extension in an effort to preserve the blood supply of the flap. A papillae sparing incision (parapapillary incision) may be used to preserve blood supply to the delicate interdental papillae and to minimize the potential of postsurgical recession [91,92] (Fig. 4). Implant placement without incision is mentioned in the literature [93]. In this procedure, the implant is placed into predetermined abundant bone through an opening made by a soft tissue punch. There is insufficient data to properly evaluate this procedure, but the author does not recommend it because this approach does not permit adequate visualization of the bone. Such visualization is necessary for proper three-dimensional positioning of the implant.

Fig. 4. Papillae sparing incision. Avoidance of papillae reflection minimizes postsurgical recession.

To achieve a successful esthetic result and good patient satisfaction, implant placement in the esthetic zone demands a thorough understanding of anatomic, biologic, surgical, and prosthetic principles. The ability to achieve harmonious, indistinguishable prosthesis from adjacent natural teeth in the esthetic zone is sometimes challenging. Placement of dental implants in the esthetic zone is a technique-sensitive procedure with little room for error. Guidelines are presented for ideal implant positioning and for a variety of therapeutic modalities that can be implemented for addressing different clinical situations involving replacement of missing teeth in the esthetic zone.

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