Development of Gingival Esthetics in the Edentulous Patient with Immediately Loaded, Single-Stage, Implant-Supported Fixed Prostheses: A Clinical Report

Richard P. Kinsel, DDS[1]/Robert E. Lamb, DDS, MSD[2]

Many clinicians have reported on the success of immediately loaded implants supporting a bilaterally stabilized provisional fixed prosthesis. This protocol offers several advantages, including increased masticatory function, minimized uncontrolled transmucosal loading through cross-arch stabilization, improvement of psychologic well-being, and reduction in treatment time. However, the development and maintenance of proper dentogingival esthetics in the edentulous maxilla presents substantial challenges for the implant team. This article presents the specific pretreatment diagnostic requirements for immediate loading of single-stage implants and demonstrates a new surgical technique, followed by appropriate prosthodontic management, to develop an optimal gingival profile with interdental papillae surrounding a natural-looking dentition. One hundred fifty-one ITI implants were placed into 22 dental arches and immediately loaded with a 1-piece fixed prosthesis. The results of this technique over the last 5 years are presented. (Int J Oral Maxillofac Implants 2000;15:711–721)

Key words: *dental implants, endosseous dental implantation, gingival papilla, implant-supported dental prosthesis, osseointegration, surgical flaps*

Osseointegrated dental implants have profoundly altered prosthodontic treatment options for the edentulous patient. The literature[1–3] is unequivocal for successful, long-term prognosis for multiple endosseous implants placed into the mandibular symphysis supporting a fixed prosthesis. Similar results have been reported for the nonsubmerged, 1-piece implant.[4]

Several authors[5–17] have reported on the immediate loading of implants that are cross-arch–stabilized with either a rigid bar connector or a fixed provisional prosthesis. Tarnow et al[11] concluded that an interim fixed, bilaterally stabilized prosthesis can provide protection from excessive micromotion while accelerating the bone adaptive process to dynamic stress relative to the unloaded protocol. Other authors[13,16,17–20] have also demonstrated that the survival of immediately loaded dental implants can be analogous to the unloaded protocol, provided that the implant has primary stability.

The present state of the art of implant dentistry, coupled with ever increasing esthetic expectations of patients, continually challenges the surgical, prosthodontic, and dental technician treatment team. Many clinicians[21–43] have recognized the importance of the gingival frame surrounding the implant restoration in completing the illusion of natural teeth. Successful implant therapy is no longer judged by whether or not the implant simply osseointegrates. Precise duplication of the color, contour, and vitality of the natural dentition alone may ultimately result in an esthetic failure if the optimal gingival profile and underlying supporting osseous structures are absent.

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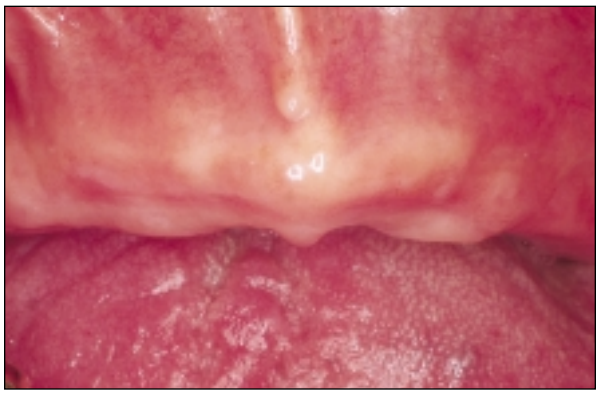
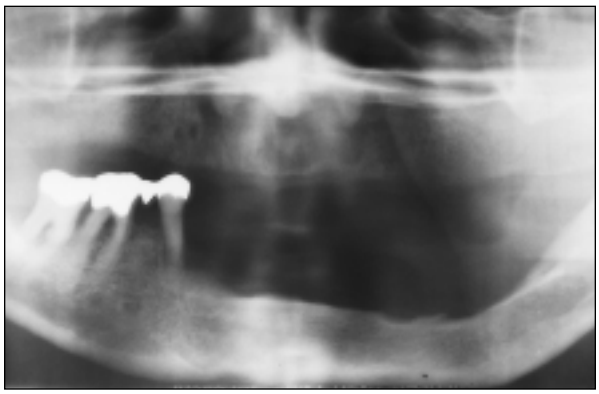




Figs 1a and 1b Clinical and radiographic views of a 70-year-old male in good health who was edentulous in the maxillary arch for over 15 years. Note the typically flat soft and hard tissue morphology that accompanies multiple tooth extractions and prosthetic restoration with a complete denture.

It is proposed that dental implants placed into an edentulous arch and immediately restored with a fixed provisional prosthesis offer a unique opportunity to enhance the gingival contours and generate interdental papillae, thus simulating the natural dentition. The new surgical technique is directed toward the creation of positive osseous contours surrounding the implants and simultaneous interproximal soft tissue augmentation, followed by appropriate prosthodontic management.

MATERIALS AND METHODS

The edentulous patient chosen to demonstrate the surgical and prosthodontic procedures was a 70-year-old male in good general health who was edentulous in the maxilla and had used a conventional complete denture for over 15 years (Figs 1a and 1b). The flat gingival and osseous topography typical of the edentulous patient would result in an implant-supported fixed prosthesis without interdental papillae and proper gingival contours if the treatment team followed conventional implant surgical and prosthodontic protocols.

Surgical Preparation

Careful pretreatment evaluation of the prospective immediately loaded implant patient is of paramount importance. Improper patient selection and imprecise placement of dental implants will lead ultimately to insurmountable prosthodontic complications. Initial evaluation begins with a thorough medical and dental history, with clear elucidation of the patient's treatment goals. The following should be noted on visual inspection: relationship of the maxillary edentulous ridge relative to the mandibular arch, adequacy of facial lip support with and without the existing prosthesis in place, presence of osseous or soft tissue defects that may require augmentation, the vertical position of the anterior ridge relative to the vermilion border during full smile and in repose, adequacy of attached keratinized gingiva, tissue quality, and initial perception of the osseous width through palpation.

Diagnostic casts were mounted on a semi-adjustable articulator using a facebow transfer and centric relation recorded at the appropriate vertical dimension of occlusion. The prosthodontist is then better able to evaluate the skeletal arch relationship, the resorptive pattern in all 3 planes, gingival topography, and any need for tissue augmentation or plasty. A prospective tooth size and arch width arrangement was selected. A wax palatal baseplate without a facial flange allowed stable transfer to the patient's mouth for visual inspection of the tooth arrangement, relationship to the residual ridge, and lip support provided solely by the denture teeth.

The accepted trial arrangement was duplicated in clear acrylic resin and served as both radiographic and surgical guides. The radiographic guide was fabricated with parallel holes placed at the prospective implant sites and obturated with gutta percha. A series of multidirectional tomograms were exposed for detailed evaluation of the osseous structures. The surgeon and restorative dentist decided upon the appropriateness of each prospective recipient site, the implant diameter and length, and whether angulation of the implant was required.

The gutta percha markers were then removed and the radiographic guide was modified to accept a 2.2-mm drill at the desired implant sites. Angulation of the implants was determined from the facial and palatal contours as viewed in the tomograms

and the surgical guide adjusted accordingly. It is crucial that the coronal portion of the implant be placed within the confines of the provisional prosthesis abutment. Although parallelism of the surgical guide holes is preferred, judicious contouring of solid abutments can accommodate slight angulation.

The provisional fixed prosthesis was fabricated in heat-processed acrylic resin (Myerson Special, Austenal Inc, Chicago, IL) from the diagnostic arrangement, which had been invested in a flask (Handler Manufacturing Co, Westfield, NJ) designed for complete-arch acrylic restorations. Different colors were used to develop neck, body, and incisal effects. The processed provisional restoration was deflasked and finished. Acrylic resin was removed from the tissue side of the prospective abutment sites in preparation for intraoral relining. Both the surgical guide and provisional prosthesis were tried in the patient for verification.

Surgical Technique for Interdental Papilla Development

The placement of multiple dental implants at positions that correspond to the predetermined abutments of the provisional fixed prosthesis requires precise tolerances. Therefore, a predictable method for accurate transfer of positioning information from the surgical guide to the dental arch is needed. A potential complication often unnoticed by the surgeon is inadvertent movement of the surgical guide during the initial implant osteotomies. The cumulative effect could lead to implants that emerge mesial or distal to the predetermined root position. Therefore, rigid fixation of the guide to the underlying palatal bone with screws is recommended to facilitate this important procedure.

After appropriate anesthesia was administered, the surgical guide was positioned on the maxillary arch, and 2 holes, slightly larger in diameter than the bone screws being utilized to secure the guide, were drilled in the anterior and posterior midpalatal region of the maxillary guide (Fig 2a). Stainless steel bone fixation screws (OsseoFix, Implant Innovations Inc, West Palm Beach, FL) 3 mm longer than the combined width of the guide and gingival tissue were used to secure the guide. The centric relation and midline positions of the guide were again verified after the guide was secured to the underlying bone. The vertical dimension of occlusion was recorded from measurement of 2 facial reference markings.

The centers of the desired implant and pontic locations were transferred to the soft tissue with a small round bur through the 2.5-mm-diameter guide holes. The surgical guide was then removed, leaving the round bur markings to guide the incision outline (Fig 2b). A 5-mm tissue punch (Punch Implant Uncovering, Ace Surgical Supply Co, Brockton, MA), which corresponds to the coronal diameter of the ITI implant (Institut Straumann AG, Waldenburg, Switzerland) and was modified by cutting the punch in half, was used to outline the palatal or lingual margins of each implant and pontic site (Fig 2c). These full-thickness semicircular incisions were connected with full-thickness crestal incisions, and partial-thickness crestal incisions were extended 10 mm distal to the terminal implant sites, where they were connected to partial-thickness vertical incisions into the buccal vestibule (Figs 2d and 2e).

The facial full-thickness flap was elevated, except distal to the terminal implant, where the flap was partial-thickness from the crest of the ridge to the mucogingival junction. The palatal tissue was not elevated from the underlying bone. Once the incisions were completed and the facial flap was reflected, the proper surgical guide position was confirmed and bone fixation screws were used to rigidly secure the guide. It was important that the surgical guide be fabricated without a facial flange to allow visibility and access for the surgical coolant. The guide holes allowed the small round bur and the 2.2-mm-diameter pilot drill to pass through and precisely position the emergence of the implants using the standard surgical protocol (Fig 3). After the 2.2-mm-diameter holes were drilled, locating the center of the definite implants, the surgical guide was removed. The crest of the alveolar ridge was flattened in the areas of implants and pontics, leaving osseous peaks to support the interdental papillae. The anatomy of the osseous ridge may require that the holes for the implants be drilled at an angle slightly off vertical to keep the implant body within bone. However, the coronal portion of the implant must be positioned to locate the abutment in the middle of the crown of the provisional prosthesis.

Osseous contouring of the alveolus was completed prior to implant placement. Interproximal vertical grooves and osteoplasty to remove excessive ledges produced the positive architecture that served as the scaffold for the resulting soft tissue contours. Appropriately sized solid, threaded ITI implants were placed until the rough surface was submerged without countersinking. Solid 4.0-mm abutments were connected into the implants and tightened to 35 Ncm (Fig 4). Angulation concerns that would interfere with placement of the provisional prosthesis were corrected by intraoral preparation of the solid abutments with an appropriate bur under copious water spray. Titanium debris was isolated from the reflected flap and underlying bone with a specialized high-speed evacuator (Clean Up Set, Scania Dental AB, Knivsta, Sweden).

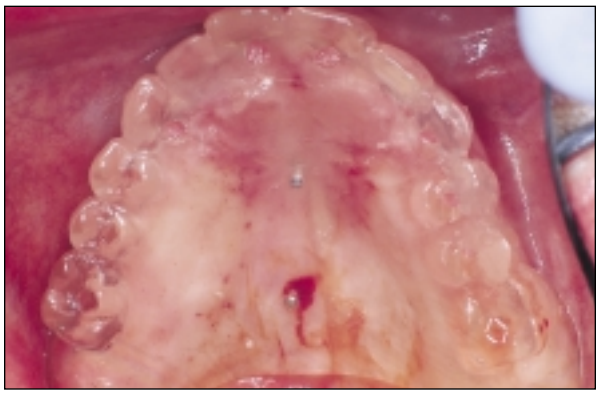


Fig 2a The surgical guide is positioned on the maxillary arch. Stainless steel bone fixation screws rigidly secure the guide to the mid-palate.

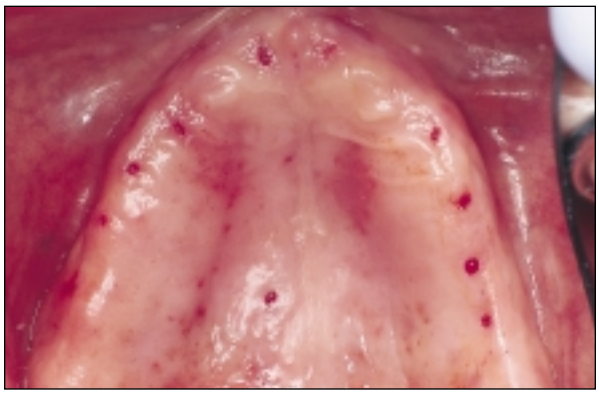
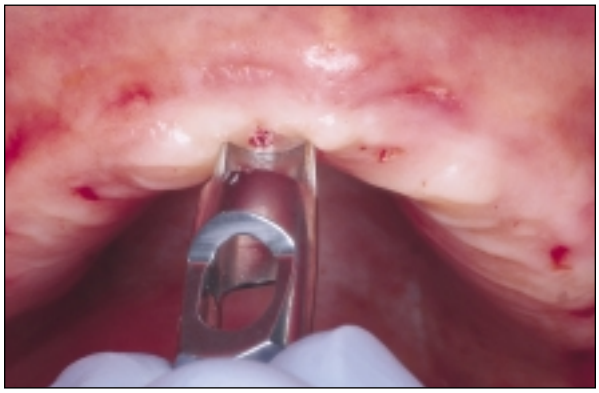
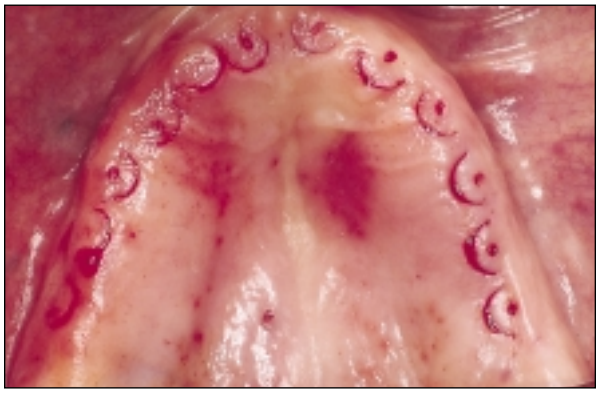


Fig 2b The desired implant and pontic locations are transferred through the guide holes to the soft tissue with a small round bur. The round bur markings are used to guide the incision outline.





Figs 2c and 2d A 5-mm tissue punch that has been cut in half is used to outline the palatal margin of each implant and pontic site.

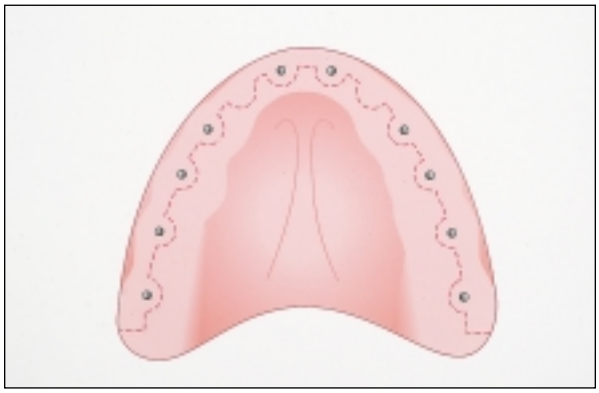


Fig 2e These semicircular incisions are connected with a full-thickness crestal incision, and partial-thickness crestal incisions are extended 10 mm distal to the terminal implant sites, where they are connected to partial-thickness vertical incisions into the buccal vestibule. The facial flap is elevated as a full-thickness flap, except for distal to the terminal implant, where the flap is partial-thickness from the crest of the ridge to the mucogingival junction, where it then becomes full-thickness.

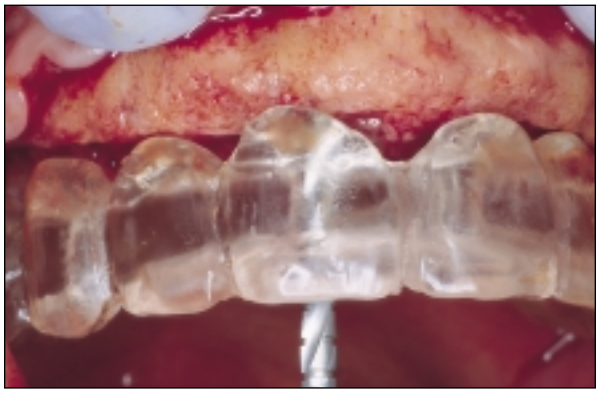


Fig 3 Bone fixation screws in the guide are returned to the mid-palate holes and secured. Stabilization of the guide facilitates precise placement of the implants within the required confines of the prosthesis. The guide holes in the surgical template allow the 2.2-mm-diameter drill to pass through and precisely position the emergence of the implants. After the 2.2-mm-diameter holes are drilled, indicating the center of the final implants, the surgical guide is removed and the ridge is flattened in the areas of implants or pontics, leaving osseous peaks to support the interdental papillae.

The provisional restoration was relined with an autopolymerizing acrylic resin (Myerson Special, Austenal Inc). The mandible was guided into the centric relation position, and proper vertical dimension of occlusion was confirmed by reproduction of the distance between 2 previously marked facial reference points. Care was taken to periodically lift and reseat the provisional prosthesis while the resin set to avoid potential undercuts inherent in the coronal flaring of the implant. The provisional restoration was finished and polished, with special attention given to the development of a definite cementoenamel junction analogous to the natural dentition. Gingival embrasures were initially enlarged to accommodate the anticipated postsurgical swelling of the newly generated interdental papillae. The provisional fixed prosthesis was completed with papilla-suspending suture holes placed into each connector. The provisional restoration was cemented onto the solid abutments with IRM luting agent (Dentsply International, Milford, DE), and excess cement was thoroughly removed.

The facial flap was laterally repositioned mesially, so the keratinized tissue from the implant and pontic recipient sites became the facial aspect of the interdental papillae (Figs 5a and 5b). A vertical mattress suture was placed through the facial aspect of the new facial interdental papilla and the needle passed to the palatal through the suture hole in each connector of the provisional restoration. A vertical mattress suture was then placed into the palatal or lingual tissue and the needle passed backward through the same suture hole. Finally, the sutures were tied facial to each new interdental papillae.

The suturing technique was modified at the midline. A horizontal mattress suture approximated the tissue that had been moved mesially from both central incisor recipient sites prior to securing this suture to the palatal tissue through the hole in the midline connector. The partial-thickness flap distal to the terminal implants was moved mesially with the rest of the facial flap and secured around the facial and distal surfaces of the terminal implant, with an interrupted suture to the palatal or lingual tissue. The facial and palatal views of the wound approximation and suspensory sutures are shown in Figs 6a to 6e. The sutures were removed 3 weeks after surgery.

Approximately 6 weeks after implant placement, the provisional prosthesis was removed and the gingival embrasures were modified by broadening the interproximal emergence profile. This compresses the interdental papillae, facilitating coronal movement of the gingival tissue.

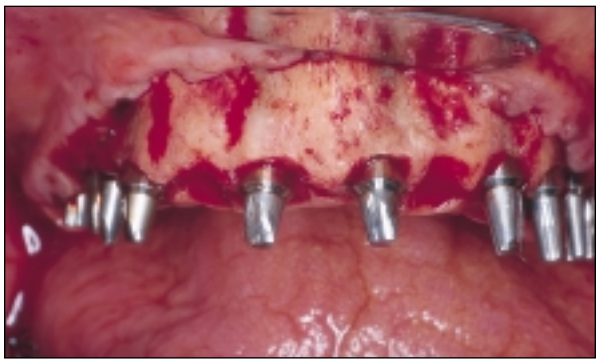


Fig 4 Osseous contouring of the alveolus is completed prior to implant placement. Vertical interproximal grooves and osteoplasty to remove excessive ledges produce the positive architecture that will serve as the scaffold for the soft tissue contours. The implants have been placed until the rough surface is submerged, with no countersinking. Solid 4.0-mm abutments are connected to the implants and tightened to 35 Ncm, or less if the implant body begins to rotate. The heat-polymerized provisional fixed prosthesis is relined. Care must be taken to periodically lift and reseat the provisional prosthesis while the resin sets to avoid potential undercuts inherent in the coronal flaring of the implant body. The finished provisional restoration is cemented with a reinforced zinc oxide–eugenol and the excess cement is removed.

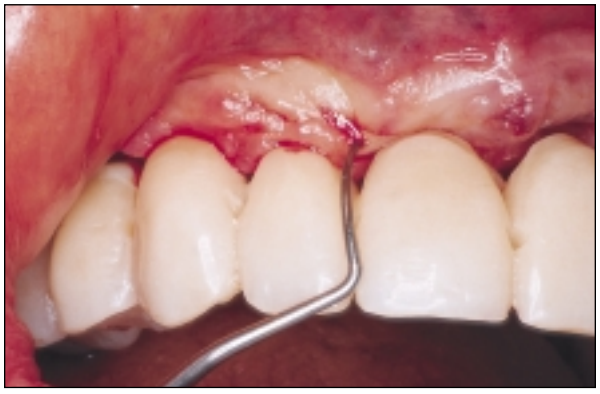


Fig 5a The facial flap is laterally repositioned mesially so that the tissue from the implant or pontic recipient sites becomes the facial aspect of the interdental papillae. Adequate reflection of the facial flap allows the tissue to be positioned without tension.

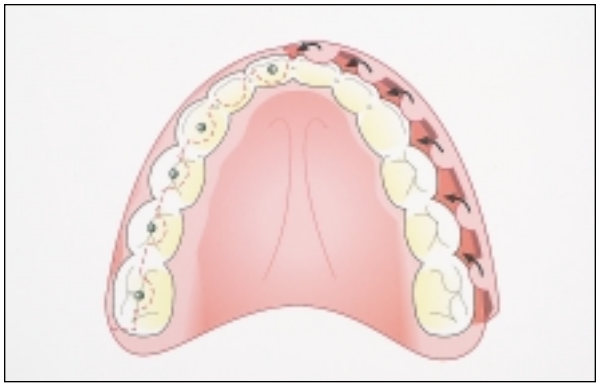
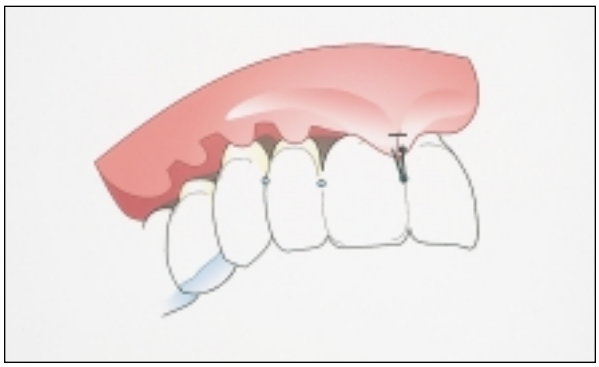
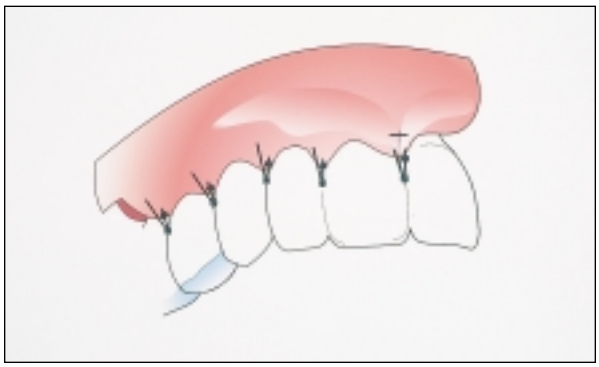


Fig 5b Mesially positioned facial flap from the posterior to the midline.





Figs 6a and 6b The suturing technique begins at the facial midline with a horizontal mattress suture used to approximate the tissue that was moved mesially from both central incisor recipient sites prior to securing this suture to the palatal or lingual tissue via the hole in the connector between the central incisors. The facial flap is laterally repositioned mesially so that the tissue from the implant and pontic recipient sites becomes the facial aspect of the interdental papillae.

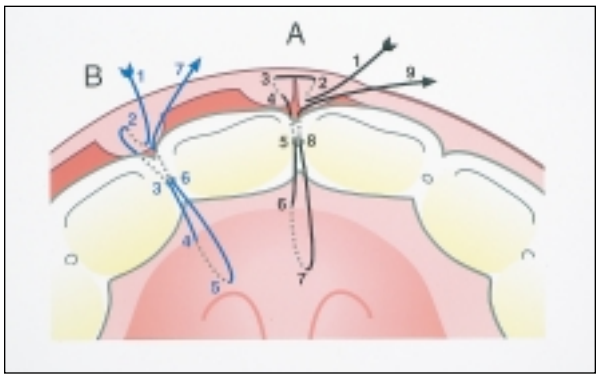
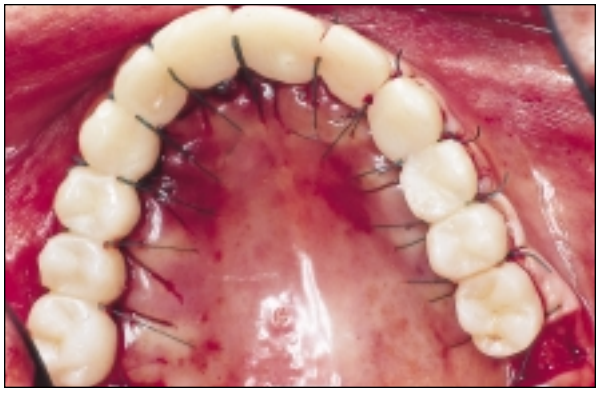
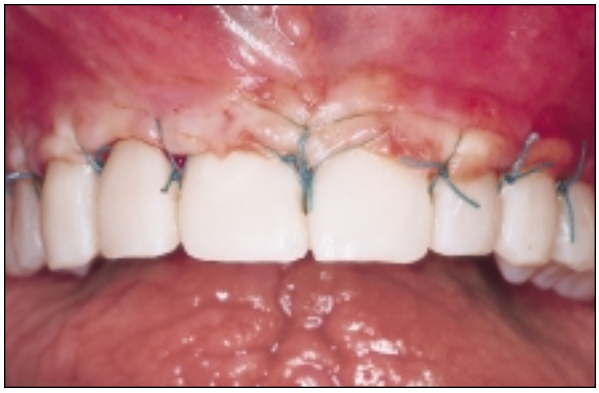


Fig 6c A vertical mattress suture is placed through the facial aspect of the new facial interdental papilla and the needle is passed to the palatal through the suture hole in each connector of the provisional prosthesis. A vertical mattress suture is then placed into the palatal or lingual tissue and the needle is passed backward through the same suture hole. Finally, the sutures are tied facial to each new interdental papilla. The partial-thickness flap that was distal to the terminal implants is moved mesially with the rest of the facial flap and secured around the facial and distal surfaces of the terminal implant with an interrupted suture to the palatal or lingual tissue.





Figs 6d and 6e Facial and palatal views of the wound approximation and suspensory sutures. The sutures are removed 3 weeks after surgery.

Final Prosthetic Treatment

Three to 4 months postsurgery, the provisional prosthesis was removed, and the solid abutments were tightened to the recommended torque of 35 Ncm to confirm bone integration. A favorable radiographic and clinical appearance, plus an absence of implant movement and painful sensation by the patient during the abutment tightening procedure, are general indications of successful osseointegration.

Final preparation of the solid abutments and, if necessary, the coronal portion of the implant to achieve esthetic, intrasulcular crown margin placement, was completed with carbide finishing burs (#H375R-023, #7408-023, Brasseler USA, Savannah, GA). A large rotary diamond bur (#806-314, Brasseler USA) was used for gingivoplasty of the edentulous ridge to create an ovate pontic form prior to relining the provisional prosthesis with

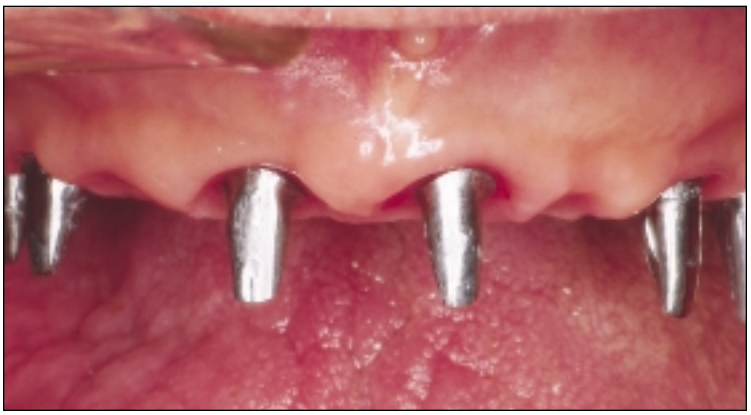
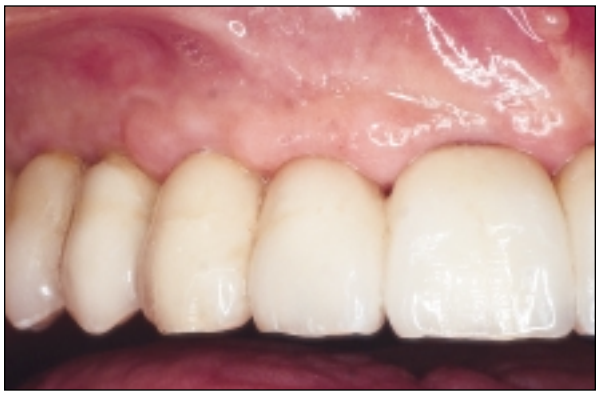
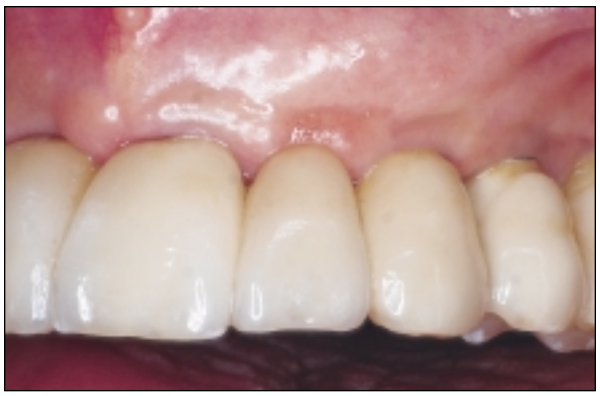


Fig 7a Once the implants have successfully integrated, the solid abutments and the gingival margins of the implants can be prepared with finishing burs.





Figs 7b and 7c The final prosthesis consisted is cemented with a glass-ionomer luting agent (Fuji I, GC Corp, Tokyo, Japan). The facial gingival contours follow the harmonious outlines that typically surround a natural dentition.

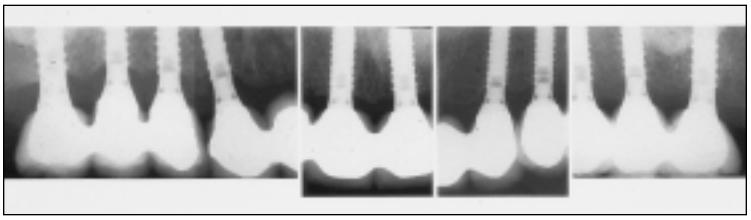


Fig 7d Radiographs demonstrate the osseous contouring and the location of the implant-crown interface relative to the alveolar crest. The distance of this microgap is positioned at least 2 mm from the bone crest, thereby preserving the biologic width and reducing potential bone resorption. Note also the interseptal bone height that serves to support the interdental papilla.

acrylic resin. Impressions for casts, facebow transfer, and centric relation records were made in the customary method. A cast of the provisional prosthesis in situ served as a template for the framework design and porcelain application.

Conventional techniques for the metal framework try-in and intraoral indexing with verification of the soldered framework accuracy were completed. It is imperative that a soft tissue master cast be fabricated to transfer the contour of the soft tissues and facilitate proper porcelain application. Special attention is directed toward the contours of the cementoenamel junction and gingival embrasures of the final prosthesis. The gingival embrasure dimensions must be biologically acceptable; however, the volume and distance from the contact point to the interseptal bone must also facilitate the maintenance of interdental papillae.

The appearance of the soft tissue profile following placement of the definitive ceramometal fixed prosthesis mirrors the facial and interproximal contours that are typically found surrounding a healthy, natural dentition (Figs 7a to 7d). Periapical radiographs demonstrate the marginal fit of the prosthesis, osseous relationship to the roughened surface and implant-crown microgap, and the positive osseous architecture with support for interdental papillae.

Table 1 Results of Immediate Implant Placement

Patient	Location (tooth no.*)	Length (mm)†	Date loaded	Failures (site no.)
JB	4, 6, 8, 9, 11, 13	**8, 10, 10, 10, 8, 8**	10/28/99	1 (#4)‡
LB	4, 6, 8, 9, 11, 13	**6,** 13, 12, 13, 13, **6**	7/23/98	0
LB	20, 21, 23, 27, 28, 29	8, 10, 12, 12, 10, 12	8/6/98	0
JC	20, 21, 23, 27, 28, 29	**10,** 12, 13, 13, 12, **10**	3/17/98	0
DC	4, 6, 8, 9, 11, 13	**9,** 11, 13, 13, 11, **9**	11/16/97	0
DD	4, 5, 6, 7, 10, 11, 12, 13	**6,** 8, 13, 10, 12, 13, **8, 6**	1/2/98	1 (#5)§
DD	19, 20, 21, 23, 28, 29	10, 12, 14, 16, 16, 12	7/17/96	1 (#20)§
BD	4, 5, 6, 7, 9, 10, 12, 13	**6,** 11, 11, 9, 13, 13, 9, **6**	2/10/97	0
BD	20, 21, 22, 27, 28, 29	11, 11, 14, 14, 11, 11	2/10/97	0
JH	4, 5, 6, 7, 10, 11, 12, 13	**9, 8, 12,** 13, **9, 9, 8, 9**	7/30/98	0
JJ	3, 4, 5, 6, 8, 9, 11, 12, 13, 14	**10,** 10, 12, 14, **12, 12,** 14, 14, 12, **10**	5/6/99	0
KJ	21, 24, 26, 28	**12,** 12, 14, 12	8/9/99	0
MK	4, 5, 6, 7, 8, 9, 10, 11, 12, 13	**8, 8,** 12, 10, 10, 10, 10, 12, 8, **8**	1/3/96	0
MK	21, 22, 24, 26, 27, 28	**10, 12,** 12, 10, **12, 10,**	1/3/96	0
IM	5, 6, 7, 10, 11, 12	12, 14, 14, 14, 14, 14	7/3/96	0
TM	4, 5, 9, 11, 13, 14	*10*, **12**, 10, **10**, *8*, *8*	6/1/00	0
FS	3, 4, 5, 6, 8, 9, 11, 12, 13, 14	**6, 10, 12,** 14, **14, 14,** 14, **12, 8, 8**	4/23/98	0
FS	19, 20, 21, 24, 26, 28, 29, 30	**12, 14, 14,** 14, 14, 14, **14, 12**	4/23/98	0
FWS	4, 5, 6, 8, 9, 11, 12, 13	**12,** 16, 16, 12, 10, 14, 14, 8	3/10/99	0
FWS	20, 22, 24, 27, 29	12, 14, 12, 12, **10**	3/17/99	0
EW	3, 4, 5, 8, 9, 13, 14	**12, 12, 10, 12, 12, 10, 10**	1/31/00	0
WW	5, 6, 9, 11, 12	12, **14, 12, 14, 12**	6/7/99	0

*Universal system.
†All implants were ITI (Straumann) standard solid-screw implants with either 3.3-mm (n = 84), 4.1-mm (n = 64), or 4.8-mm diameter (n = 3). Bold numbers connote 4.1-mm implants; italics connote 4.8-mm implants.
‡Distal abutment of provisional fixed prosthesis that fractured between the connector.
§The failures were in the same patient and at the sites of the most distal abutments. Risk factors included a chronic bruxism/clenching habit and poor maxillary bone quality.

Table 2 Total Implants by Dental Arch

Location	No. of arches	Implants placed	Survival rate (%)	Time period
Maxilla	14	104	102 (98.1)	1/96 to 6/00
Mandible	8	47	46 (97.9)	1/96 to 10/99
Total	22	151	148 (98.0)	1/96 to 1/00

All failures occurred prior to fabrication of the definitive fixed prosthesis.

RESULTS

The results of 151 ITI implants consecutively placed in 22 dental arches (14 maxillary and 8 mandibular) and immediately loaded with a fixed provisional prosthesis are shown in Tables 1 and 2. At least 4 implants were utilized to support the provisional prosthesis. The implant lengths ranged from 6 to 16 mm, with diameters of 4.8 mm (n = 3), 4.1 mm (n = 64) and 3.3 mm (n = 84). Distal cantilevers were avoided in all provisional prostheses. The time period for immediate loading ranged from January 1996 to January 2000, and currently all patients have been restored with definitive porcelain-fused-to-metal fixed prostheses. All definitive fixed prostheses were a 1-piece, rigid connector design, with the exception of 1 patient who had implants placed distal to the second premolar region. Accommodation for anticipated mandibular flexure required that the definitive fixed prosthesis be separated between the first and second premolars. Examination of the post-placement panoramic and periapical radiographs revealed no atypical bone loss.

Three of the 151 implants placed and immediately loaded were lost in 2 patients prior to fabrication of the definitive prosthesis, for an overall survival rate of 98.0% (98.1% for the maxilla and 97.9% for the mandible). It is interesting to note that all implant failures that occurred were at the most distal abutments of the provisional prostheses. One patient (DD) had type 3 and 4 bone quality and exhibited severe bruxism. The other failure (JB) was the distal abutment, which experienced a fracture of the connector of the provisional prosthesis after 2 weeks. Therefore, the failures may be attributed to macromovement of the implant, which resulted in fibrous encapsulation instead of osseointegration. These results compare favorably with those of Tarnow et al,[11] Salama et al,[12] Levine et al,[16] and Randow et al,[17] which demonstrate survival comparable to those obtained with a conventional protocol of delayed loading following osseointegration.

Table 3 Results of Papilla Generation at 136 Sites (Jemt Classification[43])

Patient	Class 0 (no papillae)	Class 1 (< 50% closure)	Class 2 (> 50% closure)	Class 3 (100% closure)
JB	0	0	0	9
LB	0	2	2	5
DC	0	2	5	2
BD	0	2	5	4
DD	0	1	3	7
FE	0	0	4	5
FF	0	0	3	6
JH	0	0	0	9
JJ	0	0	0	11
MK	0	0	2	7
IM	0	0	2	7
FS	0	2	7	2
EW	0	0	3	8
WW	0	1	3	5
Totals (%)	0	10 (7.3%)	39 (28.7%)	87 (64.0%)

Jemt[43] has proposed an index to assess the size of the interproximal gingival papillae adjacent to single implant restorations. These would range from 0 to 4, representing in order: no papilla, less than one-half the height of the gingival embrasure, at least one-half the height, complete closure of the proximal space, and overgrowth. Table 3 shows the results of papilla generation for those patients treated with the protocol described in this report using Jemt's classification. In the 14 maxillary arches (136 interproximal sites) that were examined following placement of the definitive prosthesis, 64.0% of the papillae completely occluded the embrasure space, 28.7% were greater than one-half of the distance to the contact point and 7.3% were less than one-half. There were no sites with either gingival overgrowth or absence of interproximal papillae.

DISCUSSION

Currently, there is a confluence of treatment procedures that directly impact the delivery of implant services. Implant dentistry has experienced advances in soft and hard tissue augmentation, precise radiography, and basic research related to the influence of implant surface microtopography on cell biology, the importance of biologic width, and the apparent success of immediate functional loading of implants. The protocol for evaluation and prediction of final gingival contours surrounding single or short-span implant-supported fixed prostheses has been previously discussed. However, the implant team remains challenged when several adjacent teeth have been lost or in the edentulous patient, where it is necessary to replace missing gingival contours.

The implant team can provide what is required for increased masticatory function by minimizing the effects of uncontrolled transmucosal loading through cross-arch stabilization. With the present technique, clinicians can improve patients' psychologic well-being, reduce treatment time, and develop root prominences and esthetic gingival contours, including formation of interdental papillae.

One caveat to the apparent successes reported by many clinicians is the long-term consequence of immediate loading. These patients will require continued recall and evaluation to ascertain whether there are any qualitative differences in the osseointegration phenomena occurring under loaded or unloaded conditions. In this report, radiographs taken 6 months postsurgery showed maintenance of interseptal bone height. However, follow-up at 3 to 5 years to determine the clinical appearance of interproximal papillae and evaluate the osseous support will be required to confirm the prospects of long-term stability of this procedure.

Salama and colleagues[34, 35] have stressed the importance of the osseous architecture in the ultimate form of the gingival contours. They suggested that the relationship of the underlying bone supporting the interdental papillae between natural teeth is similar to peri-implant papillae. The most predictable esthetic results can be accomplished only when underlying labial and interproximal osseous support is therapeutically provided for the desired soft tissue contours. Also, they found that the loss of multiple adjacent teeth creates the greatest propensity for

interproximal bone loss, which will compromise the foundation of future papillae. Therefore, they recommended that where 3 or more consecutive teeth are being replaced and sufficient bone is available to place implants of adequate length, it is preferable to alternate the arrangement of implants and ovate pontics to optimize soft tissue esthetics.

Takei and coworkers[36] and Phillips and Kois[37] also emphasized the relationship of soft tissue osseous support. They emphasized that the amount of interproximal gingival scallop is related to the amount of interproximal osseous scallop. The greater the discrepancy between the apex of the interdental papilla and the underlying bone, the less predictable is complete obturation of the gingival embrasure. Kois[38] has suggested that square-shaped crowns and flat proximal surfaces with contact points as gingival as possible will facilitate the growth of papillae provided that adequate osseous support is available.

Soft tissue surgical techniques to augment the interproximal gingiva have been presented previously. Palacci[39, 40] and Andreasen et al[41] have developed a rotated pedicle graft technique to increase the interproximal volume at the time of transmucosal abutment connection using the 2-piece submerged implant. Adriaenssens et al[42] recently described a gingival flap design they coined as "the palatal sliding strip flap," performed at second-stage surgery of the 2-stage dental implant to develop papillae between implants in the anterior maxilla. The flap is designed so that the palatal tissue is displaced in the labial direction to increase the volume of interproximal tissue.

Several authors have reported on the uniqueness of the interdental papilla as compared to the facial and lingual gingival margins.[33,44,45] Although underlying osseous support is crucial to papilla height, other important factors include distance from the osseous peak to the interproximal contact of prosthetic teeth, volume and shape of the gingival embrasure, and the vertical and horizontal distance from bacterial plaque to the interproximal bone.[46,47] Tarnow et al[48] have recently documented that significant interproximal bone loss occurs when the lateral distance between adjacent implant margins is less than 3 mm.

CONCLUSION

The regeneration and maintenance of interproximal papillae depend upon the control of multiple factors. These include interseptal osseous scaffold, placement of the single-stage implant-crown microgap a minimum of 2 mm coronal to the osseous crest without countersinking, horizontal positioning of adjacent implant plaque-retaining surfaces at least 3 mm apart, increasing the volume of keratinized gingival tissue interproximally in a tension-free manner, and proper design of the gingival embrasures of both the provisional and definitive prostheses.

The techniques described in this article require precise treatment planning and proper patient selection; skilled surgeons, restorative dentists, and laboratory technicians acting in concert; and implant surgery and immediate provisionalization completed at the same facility. The development and maintenance of interdental papillae and natural gingival contours are dependent upon the underlying osseous architecture, a volume of soft tissue that can effectively obturate the gingival embrasure, distance from the plaque front to the surrounding bone, and proper prosthodontic design.

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