The Iliac Prefabricated Composite Graft for Dentoalveolar Reconstruction: A Clinical Procedure

Kurt Vinzenz, MD, DDS[1]/Christian Schaudy, MD[2]/Elisabeth Würinger, MD[3]

Prefabricated composite grafts were introduced in reconstructive oral and maxillofacial surgery in the mid-1990s. The purpose of this report is to introduce a novel technique—the iliac prefabricated composite graft—for reconstruction of the alveolar ridge simultaneously with masticatory attached gingiva and integrated implants in a single procedure. Clinical and immunohistologic results are reported and reveal this technique to be an attractive alternative in dentoalveolar surgery and implant dentistry. Int J Oral Maxillofac Implants 2006;21:117–123

Key words: *dentoalveolar reconstruction, iliac crest, keratinized attached gingiva, prefabricated composite grafts, severe maxillary atrophy*

The seating of a bone-anchored prosthesis and/or the osteoplastic reconstruction of the defective maxilla in its anatomically appropriate shape pose a great challenge in maxillofacial surgery. Implant healing can be hampered by the poor quality and quantity of bone tissue at the site.[1,2] Moreover, the restoration of fully developed, attached gingiva in the reconstructed bony area is an even greater task.[3–6] Various multi-step reconstruction methods have been described to date.[7–16] Only in the mid-1990s were prefabricated composite grafts introduced in reconstructive oral and maxillofacial surgery.[7–26]

Encouraged by the positive results achieved with prefabricated scapular grafts for the reconstruction of patients with extensive facial defects,[23–25] investigators modified this technique to make it suitable for dentoalveolar defects, which are frequently associated with the loss of functional gingiva. This technique for osteoplastic reconstruction of the alveolus involves the application of prefabricated composite grafts from the iliac crest. It can be used to achieve the following goals: *(1)* restoration with immediate stress-bearing bone-anchored implants in a single session and *(2)* simultaneous *restitutio ad integrum* of the oral attached gingiva.

The purpose of this report was to present the surgical procedure and clinical results. In addition, histologic and immunohistologic studies were performed, and the results were compared with the published results for prefabricated scapular flaps.[3,27]

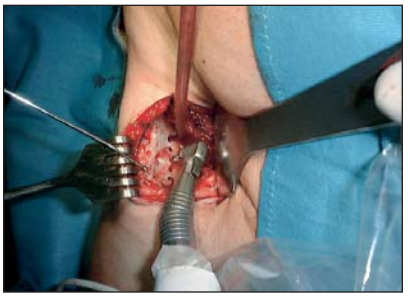
PATIENT

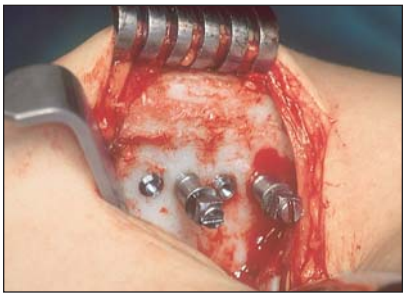
A 42-year-old male patient suffering from a subtotal loss of his postcanine maxillary alveolar ridge after several oral surgical interventions was treated with an iliac prefabricated composite graft.

Precise preplanning is a must for prefabrication of a composite graft.[8,28,29] To determine the size and shape of the transplant and for exact positioning of the endosteal implants, computerized tomographic (CT) data were acquired using a Siemens Somatom Plus 4 and HiQ in high-resolution mode (Siemens, Munich, Germany). Slices 1 to 2 mm thick were used. Initial planning was performed using a high-speed image operation system (ARRI-Voxel-Flinger; ARRI, Detroit, MI) with complete interactive 2- and 3-dimensional (3D) visualization capabilities and interactive image manipulation via graphic workstation and appropriate software. Control examinations were carried out postoperatively using the same system and sequential radiographs.

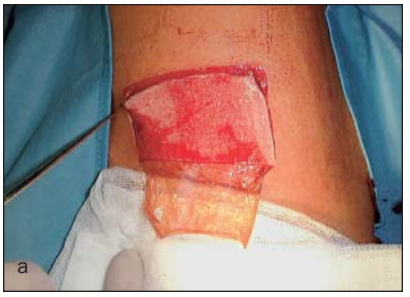
[1]Professor and Head, Department of Oral-Maxillo-Facial Surgery, Evangelisches Krankenhaus Vienna, Austria.
[2]Clinical and Scientific Assistant, Department of Oral-Maxillo-Facial Surgery, Evangelisches Krankenhaus Vienna, Austria.
[3]Resident, Department for Plastic and Reconstructive Surgery, Wilhelminenspital, Vienna, Austria.

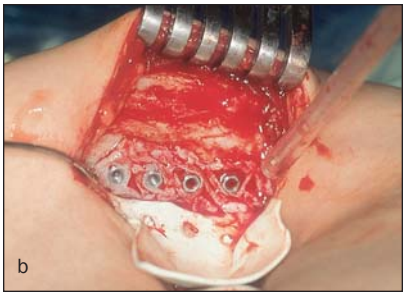
Correspondence to: Dr Kurt G. Vinzenz, Department of Oral-Maxillo-Facial Surgery, Evangelisches Krankenhaus Wien, Hans Sachs-Gasse 10-12, A-1180 Vienna, Austria. Fax: +43 1 40422 2810. E-mail: kurt.vinzenz@vienna.at

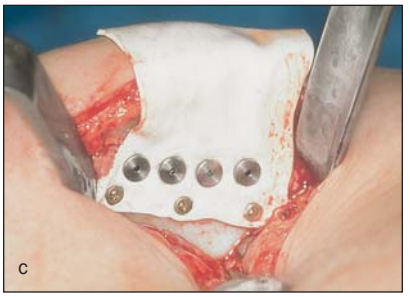




Figs 1a and 1b Prefabrication of the appropriate part of the iliac crest. According to the preoperative analysis implants were placed into the iliac crest.







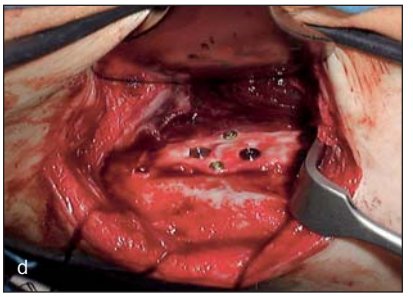


Fig 2a Epidermis was removed from the thigh, and the underlying dermis was harvested with a dermatome. The defect was subsequently covered with the epidermis.

Figs 2b and 2c Prefabrication of the appropriate area of the iliac crest. After implant placement the iliac bone was first attached with dermis and afterward with a Gore-Tex membrane. The photograph shows the dermis under the Gore-Tex membrane, which has been fixed onto the implants using cover screws.

Fig 2d The prefabricated composite graft in situ 4 months later, before the graft was harvested.

SURGERY

General Information

The graft was prefabricated in the iliac crest. Flap prefabrication included preformation of the bony flap, implant placement, and prelamination with dermis.[23–25] The need for microsurgical revascularization is dependent on the size of the bony transplant. For smaller composite grafts from the iliac crest area (up to a size of 3 to 4 cm wide), microsurgical revascularization can be omitted, according to the model developed by Marx and associates[30,31] for bone transplants. Therefore, in a variation of the procedure, the osteotomy was first carried out at the time of flap harvesting to ensure vascular circulation during the healing period of the composite graft.

Prefabrication of the Composite Graft

According to the preoperative analysis, the appropriate part of the iliac crest was liberated from the attached tissue, and endosteal titanium implants (Brånemark System MkII; Nobel Biocare, Göteborg, Sweden) were placed into position as preoperatively planned (Figs 1a and 1b). The implants placed were self-tapping screw-type implants 3.75 mm wide and 10, 13, or 15 mm long. After removal of the epidermis, dermis was harvested with a dermatome from the thigh (Fig 2a). Then the selected piece of the iliac crest was coated with dermis (Fig 2b) and covered with a Gore-Tex membrane (WL Gore and Associates, Newark, DE) (Fig 2c), which was fixed to the bone by microscrews. Subcutaneous tissue and skin were closed in layers, and the construction was left in the pelvic region.

RECONSTRUCTION OF THE ALVEOLAR RIDGE

After approximately 3 to 4 months the composite graft was harvested by osteotomy (Fig 2d). The Gore-Tex membrane was removed before the transplant was transferred into the maxillary defect (Fig 3).

According to the preoperative planning, the transplant was placed into the correct position and stabilization was achieved using titanium miniplates connected to the implants. The graft was then fixed to the maxilla using microscrews (Figs 4a and 4b). Prosthetic rehabilitation was subsequently performed.

Fig 3 The prefabricated composite graft after elevation. The dermal cover was firmly attached to the underlying bone and covered with a pseudomucosa identical to that observed in the scapula flap after 3 months of prefabrication. The implants form a dental arch, as planned, using interactive manipulation of 3D CT data.

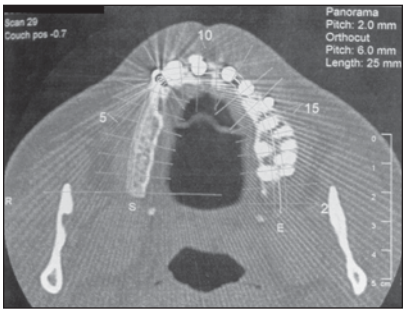


Fig 4a CT imaging before reconstruction. Pronounced atrophy of the alveolar ridge can be observed.

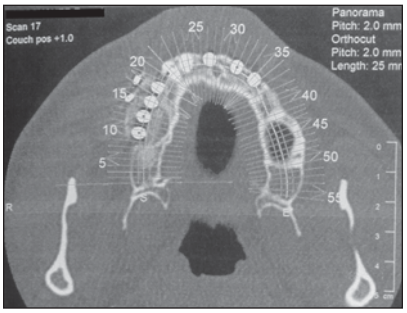
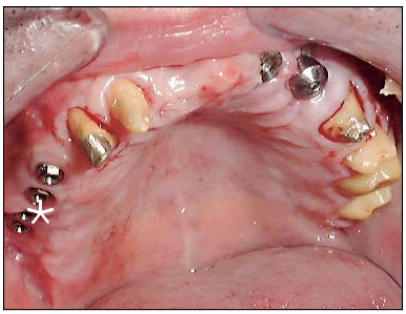
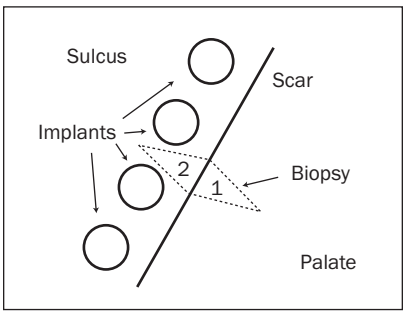


Fig 4b CT imaging after reconstruction with the prefabricated iliac flap. Complete restoration of the alveolar ridge was achieved. The dental arch was reconstructed as planned.

Fig 5a Intraoral view of the reconstructed alveolar crest 4 weeks after transfer of the graft into the oral cavity. The reconstructed mucosa is clinically indistinguishable from the surrounding normal mucosa. The asterisk (*) indicates the region where the biopsy sample was obtained.

Fig 5b Graphic illustration showing the location from which the biopsy sample was removed. Region 1 represents the natural hard palatine mucosa (the upper 4 panels in Fig 8), while region 2 represents restituted attached gingiva (the lower 4 panels in Fig 8).





HISTOLOGIC METHODS

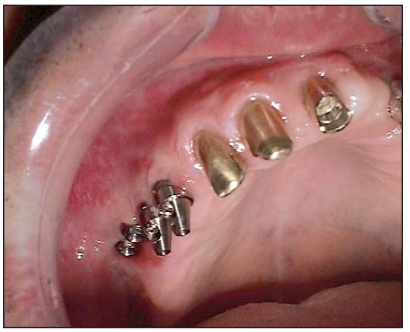
From the harvested graft, a marginal section of the prefabricated grafted tissue was removed and fixed in neutral buffered formalin (Fig 5). For the immunhistochemical pilot study, biopsies of the reconstructed "neogingiva" and hard palate were obtained 4 weeks after flap transfer in the oral cavity, in accordance with longitudinal histologic examinations in prefabricated scapula flaps.[15] Complete differentiation of the epithelium was observed at this time (Figs 5a and 5b).

The bony piece was embedded without decalcification in methyl-methacrylate resin. From the block, ground sections were prepared and evaluated by light microscopy after appropriate staining. These investigations served as clinical controls of osseointegration. Further histochemical details are described elsewhere.[30]

Immunohistochemistry

For immunohistochemical detection of keratin several antikeratins were obtained (Table 1). Biotin-conjugated anti-mouse IgG was obtained from Vector (Burlingame, CA).

Tissue samples were embedded in OCT Compound Tissue Tek (Sakura Finetek USA, Torrance, CA) and fast frozen. Five-µm-sections were cut from the frozen specimens using a cryomicrotome (Leica, Wetzlar, Germany). Each specimen was mounted onto a glass slide, air dried, fixed, and incubated overnight at 4°C with 1 of the primary mAbs (1µg/mL) diluted in phosphate buffered saline (PBS) with a pH of 7.4 containing 1% bovine serum albumin for 1 hour. After washing in PBS, sections were incubated with biotinylated anti-mouse Ab (Vector) for 30 minutes. After washing, sections were incubated with horseradish peroxidase-conjugated avidin-biotin complex (Vector). Peroxidase was visualized using 3-amino-9-ethylcarbazole (Sigma-Aldrich, Vienna, Austria). Sections were counterstained with hematoxylin (Dako, Glostrup, Denmark) and mounted in glycerol gelatin. The specificity of immunohistochemical staining was determined by replacing the primary antibody with an irrelevant antibody of the same class.



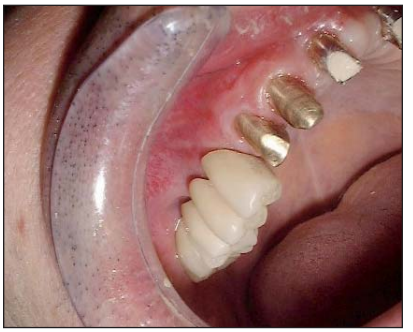


Fig 6a Reconstructed alveolar ridge with implants and abutments.

Fig 6b Reconstructed alveolar ridge after complete prosthetic restoration.

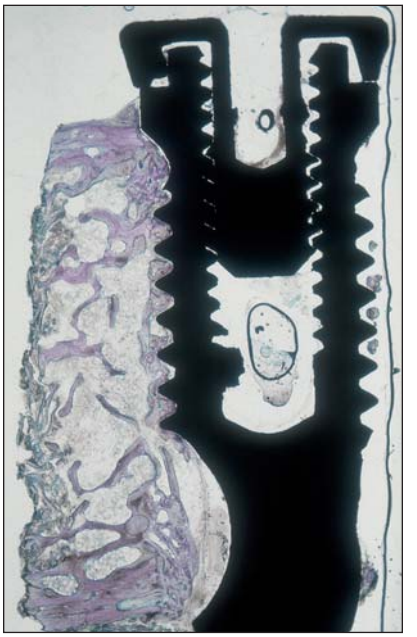


Fig 7 Ground section, of the prefabricated composite graft showing vital endosteal remodelling. The implant was found to be adequately anchored in the bony graft (Giemsa stain; original magnification × 20).

Table 1 Antikeratins

Antikeratin	Clone	Manufacturer
1,10 mAb	8.60	Progen, Heidelberg, Germany
8 mAb	M20	Neomarkers, Fremont, CA
13 mAb	1C7	Neomarkers
14 mAb	LL002	Neomarkers
16 mAb	LL0025	Neomarkers
18 mAb	DC 10	Neomarkers
19 mAb	A53-B/A2.26	Neomarkers

RESULTS

After a healing period of approximately 3 to 4 months, reconstruction of the alveolus was achieved by means of this composite prefabricated bone graft. In all cases the skin graft was attached firmly to the bony flap and had developed a delicate epithelium at the interface between dermis and the Gore-Tex membrane (Fig 6). After wound healing this "pseudogingiva" could clinically not be distinguished from that observed in a previous prefabricated scapula flap procedure[3,25] (Fig 5a). Again the implants in correct anatomic position were found to be adequately anchored in the bone and served for dental rehabilitation (Fig 6a).

The quality of intraoral reconstruction is marked by maximum restoration of natural anatomy in the oral cavity and an attached gingiva with inflammation-free points of exit for the implants. High functional and esthetic standards for bone-anchored prostheses could be achieved even in patients with extensive loss of the alveolar ridge (Fig 6b). Currently, a total of 27 patients have been reconstructed with composite bone grafts prefabricated in the iliac crest.

Histologically, the bone graft showed patterns of remodeling activity. Implants were found to be adequately anchored in the iliac crest (Fig 7). The results of the present immunohistologic analysis were compared with a previous analysis of microvascular revascularized scapula transplants.[27] Keratins are unique markers of epithelial differentiation.[31] The classification by Moll and coworkers[32] assigns a number to each keratin (keratin 1 through keratin 20) based on their relative charge, molecular weight, and reaction with monoclonal antibodies. As illustrated in the top 4 panels of Fig 8, keratinocytes of the normal hard palate mucosa express keratin 1,10 in the suprabasal layers of the epithelium (Fig 8a), together with keratin 13 (Fig 8c), the marker for "wet" epithelium, and keratin 16 (Fig 8g). The basal layer of the normal hard palate mucosa is negative for keratin 1,10 (Fig 8a), keratin 13 (Fig 8c), and keratin 16 (Fig 8g). In contrast, keratin 14 is strongly expressed in the basal as well as in the suprabasal regions of the normal oral mucosa (Fig 8e). The lower 4 panels of Fig 8 show the prefabricated flap 4 weeks after transfer to the oral cavity. The flap had developed a fully differentiated epithelium consisting of basal and suprabasal cell layers. The suprabasal keratinocytes of the reconstructed oral mucosa strongly expressed keratin 1,10 (Fig 8b), a marker for a regular differentiation, keratin 13 (Fig 8d), which is highly characteristic for "wet" epithelium, and keratin 16 (Fig 8h). Keratin 14, another marker for regular differentiation, was strongly expressed in the basal as well as in the

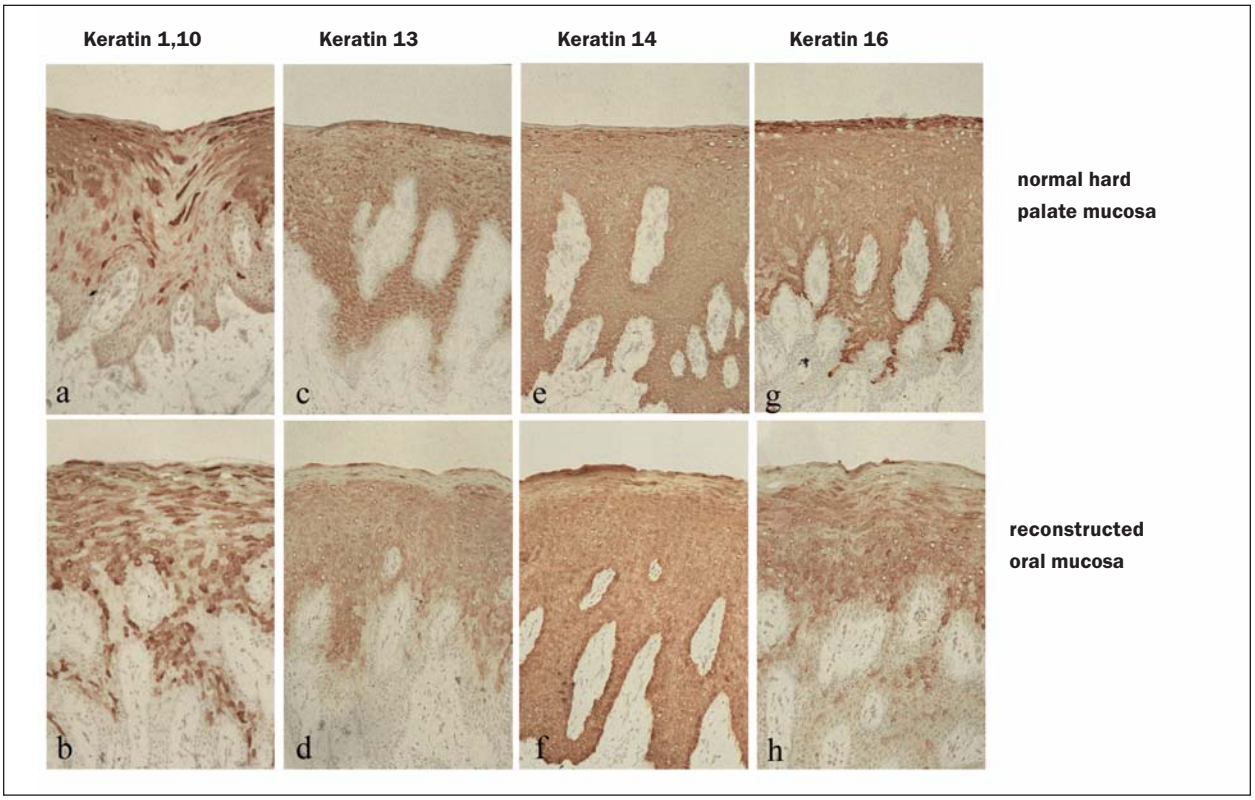


Fig 8 Immunohistochemical staining. The top 4 panels show normal hard palate mucosa. Keratin 1,10 was expressed in the suprabasal layers of the epithelium *(a)* together with keratin 13 *(c)* and keratin 16 *(g)*. Note that keratins 1,10; 13; and 16 were not expressed in the basal layers of normal hard palate mucosa. Keratin 14 was detectable in the basal as well as in the suprabasal layers of the hard palate mucosa. The lower 4 panels show the epithelium of the prefabricated iliac flap 1 month after the transfer into the oral cavity. The mucosa was fully differentiated; basal and suprabasal layers can be discerned. The suprabasal layers expressed keratin 1,10 *(b)*, keratin 13 *(d)*, and keratin 16 *(h)*. Keratin 14 was expressed in the basal as well as in the suprabasal layers of the reconstructed mucosa.

suprabasal layers of the newly developed epithelium. In all sections of the reconstructed mucosa, pronounced rete ridges, which are highly characteristic of hard palate mucosa, could be seen. The papillae extended deeply into the epithelium, providing mechanical attachment of the epithelium to the underlying tissue.

As with the analysis of prefabricated scapula transplants, both the pattern of keratin expression and the formation of rete ridges in the reconstructed mucosa were indistinguishable from normal hard palate mucosa.

DISCUSSION

Atwood described the characteristic shapes that result from resorption of the alveolar process during the gradual stages of atrophy.[33,34] Correlated with the extent of bone loss, there is a simultaneous reduction in the expanse of attached gingiva, even resulting in complete absence of masticatory gingiva in severe atrophy.[35–39] Therefore, next to the maxillary bone, the osseous alveolus in its natural form together with the masticatory attached gingiva needs to be reconstructed.[3,25] For this reason, free grafting of bone, split-thickness skin transplants, and split mucous transplants are well accepted and have been proven operation techniques since the mid-1970s.[8,35–39] Based on clinical observations of split-thickness skin grafts as well as free mucosal grafts, which are similar to free grafted bone, these grafts can survive without circulation for a short amount of time.[29,35–38]

Because of limited availability of oral mucosa, split-thickness skin grafts have been used for providing intraoral lining[35–43] as well. However, they retain their structural characteristics with texture and appearance of normal skin even after years,[41,42] therefore showing less optimal properties in terms of reaction to denture trauma and infection.[41–43] Most of these grafts have been used for vestibuloplasty, including the deepening of the labial and buccal vestibules, to improve the relative height of the alveolar ridge.[35–39,41–44] In contrast, the described surgical technique using an iliac prefabricated composite graft provides not only an intraoral lining together

with the bony reconstruction of the alveolar ridge, but also integrated implants for immediate masticatory loading in 1 procedure.

Skin and mucosa grafting have been subjects of intensive histologic evaluation since the 1970s; the biologic process of mucosa regeneration is still being investigated.

Hill and MacKenzie examined the influence of subepithelial connective tissues on epithelial proliferation in animal experiments,[45] while Boukamp and coworkers[46] concentrated on the mesenchyme-mediated and endogenous regulation of growth and differentiation of human cell keratinocytes.

A further aspect of the effects of subepithelial fibroblasts on epithelial differentiation has been introduced by Okazaki and associates.[47] Taylor and associates[48] have described the involvement of follicular stem cells in the regeneration of epidermis. The present authors' immunhistochemical investigations analyzed the keratin expression profile of prefabricated flaps' self-assembled epithelial coating. They found that epithelial cells were derived from adnexal structures of the dermal graft as well as from the edges of the coating.[27]

Recently the mucosal attachment has been a primary target of investigation, since an attached keratinized masticatory gingiva not only acts as a protective barrier, providing an adequate seal between the oral environment and the implants, but is also less vulnerable to compressive loading and shearing forces during mastication. Otherwise, tenacious scar bands frequently develop.[41–44] The role of gingival connective tissue for epithelial differentiation was introduced in 1975 by Karring and associates.[49] In a recent publication, Schlenz and coworkers[3] also described the increasing number and size of connective-tissue papillae in transplanted prefabricated scapula flaps within 4 weeks after exposure to the oral milieu.

The authors' initial immunohistochemical observations in the presented surgical concept confirm previous clinical results,[3,25,27] showing completely differentiated epithelium consisting of basal and suprabasal cell layers expressing keratin 1,10, a marker for a regular differentiation, and keratin 13, which is highly characteristic for "wet" epithelium.

In accordance with published results regarding prefabricated scapula flaps,[23–25] a high number of good-sized connective tissue papillae could be seen 4 weeks after exposure to the oral milieu.[3] Although the completely restored keratinized masticatory gingiva provides resistance to masticatory loading, the objective is to avoid mucosa-supported prostheses in all cases.

CONCLUSION

Modification of a previous operation technique for reconstruction of the alveolar ridge simultaneously with a masticatory attached gingiva and integrated implants has been introduced. Some aspects of preprosthetic surgery were also described. The results of the histologic and immunohistologic investigations correlated with those of earlier studies.[3,25,27]

ACKNOWLEDGMENTS

The authors thank Univ-Prof Dr Hanns Plenk Jr. of the Department of Bone and Biomaterials Research, Histological-Embriological Institut at the University of Vienna, Austria for his support and his permission to include Fig 7 in this work. Furthermore, the authors would like to thank Dr Rainer Kunstfeld of the Department of Dermatology, University of Vienna, Medical School (Head: Univ-Prof Dr K. Wolff) for providing the immunohistochemical analysis.

REFERENCES

1. Adell R, Eriksson B, Lekholm U, Brånemark P-I, Jemt T. A long-term follow-up study of osseointegrated implants in the treatment of totally edentulous jaws. Int J Oral Maxillofac Implants 1990;5:347–359.
2. Brånemark, P-I, Adell R, Breine U, Hansson DB, Lindström J, Ohlsson A. Intraosseous anchorage of dental prosthesis I. Experimental studies. Scand J Plast Reconstr Surg 1969;3:81–100.
3. Schlenz I, Korak K, Kunstfeld R, Vinzenz KG, Plenk H Jr, Holle J. The dermis-prelaminated scapula flap for reconstructions of the hard palate and the alveolar ridge: A clinical and histological evaluation. Plast Reconstr Surg 2001;108:1519–1524.
4. Artzi Z, Tal H, Moses O, Kozlovsky A. Mucosal considerations for osseointegrated implants. J Prosthet Dent 1993;70:427–433.
5. Krekeler G, Schilli D, Diemer J. Should the exit of the artificial abutment tooth be positioned in the region of the attached gingiva? Int J Oral Surg 1985;14:504–511.
6. Buser D, Weber HP, Bragger U. The treatment of partially edentulous patients with the ITI hollow screw implants: Presurgical evaluation and surgical procedures. Int J Oral Maxillofac Implants 1990;5:165–172.
7. Adell R, Lekholm U, Gröndahl K, Brånemark P-I, Lindström J, Jacobsson M. Reconstruction of severely resorbed edentulous maxilla using osseointegrated fixtures in immediate autogenous bone grafts. Int J Oral Maxillofac Implants 1990;5: 233–246.
8. Boyne PJ, James RA. Grafting of the maxillary sinus floor with autogenous marrow and bone. J Oral Surg 1980;38:613–616.
9. Breine U, Brånemark P-I. Reconstruction of the alveolar jaw bone. An experimental and clinical study of immediate and preformed autogenous bone grafts in combination with osseointegrated implants. Scand J Plast Reconstr Surg 1980;14:23–48.
10. Blomqvist JE, Alberius P, Isaksson S. Sinus inlay bone augmentation: Comparison of implant positioning after one- or two-staged procedures. J Oral Maxillofac Surg 1997;55:804–810.

11. Isaksson S. Evaluation of three bone grafting techniques for severely resorbed maxillae in conjunction with immediate endosseous implants. Int J Oral Maxillofac Implants 1994;9: 679–688.
12. Moy PK, Lundgren S, Holmes RE. Maxillary sinus augmentation: Histomorphometric analysis of graft materials for maxillary sinus floor augmentation. J Oral Maxillofac Surg 1993; 51:857–862.
13. Momtaheni DM, Schweitzer K, Muenchinger F. Technique for stabilization of autogenous cancellous bone grafts in sinus lift procedures. J Oral Implantol 1994;20:100–110.
14. Nyström E, Ahlquist J, Kahnberg KE, Rosenquist JB. Autogenous onlay bone grafts fixed with screw implants for the treatment of severely resorbed maxilla. Int J Oral Maxillofac Surg 1996;25:351–359.
15. Reinert S, König S, Eufinger H, Bremerich A. Techniques and results of osteoplastic reconstruction of the severely resorbed maxilla in combination with implants [in German]. Mund Kiefer Gesichtschir 1999(suppl 1):S30–S34.
16. Tolman DE. Reconstructive procedures with endosseous implants in grafted bone: A review of literature. Int J Oral Maxillofac implants 1995;10:275–294.
17. Khouri RK, Upton J, Shaw WW. Principles of flap prefabrication. Clin Plast Surg 1992;19:763–771.
18. Muzaffar AR, Adams WP, Hartog JM, Rohrich RJ, Byrd ST. Maxillary reconstruction: Functional and aesthetic considerations. Plast Reconstr Surg 1999;104:2173–2183.
19. Igawa HH, Minakawa H, Sugihara T. Functional alveolar ridge reconstruction with prefabricated iliac crest flap and osseointegrated implants after hemimaxillecomy. Plast Reconstr Surg 1998;102:2420–2428.
20. El Hussaen AA, Shenaq SM, Spira M, El Falaky MH. Prefabricated flaps: Experimental and clinical review. Plast Reconstr Surg 1995;96:1218–1227.
21. Safac T, Akyürek M, Özcan G, Kecik A, Aydin M. Osteocutaneous flap prefabrication based on the principle of vascular induction: An experimental and clinical study. Plast Reconstr Surg 2000;105:1305–1313.
22. Pribaz JJ, Weiss DD, Mulliken JB, Ericsson E. Prelaminated free flap reconstruction of complex central facial defects. Plast Reconstr Surg 1999;104:357–365.
23. Holle J, Vinzenz K, Wuringer E, Kulenkampff KJ, Saidi M. The prefabricated combined scapula flap for bony and soft-tissue reconstruction in maxillofacial defects—A new method. Plast Reconstr Surg 1996;98:542–552.
24. Vinzenz KG, Holle J, Wueringer E, Kulenkampff KJ. Prefabrication of combined scapula flaps for microsurgical reconstruction in oro-maxillofacial defects: A new method. J Craniomaxillofac Surg 1996;24:214–223.
25. Vinzenz KG, Holle J, Wueringer E, Kulenkampff KJ, Plenk H Jr. Revascularized composite grafts with inserted implants for reconstructing the maxilla—Improved flap design and flap prefabrication. Br J Oral Maxillofac Surg 1998;36:346–352.
26. Rohner D, Jaquiery C, Kunz C, Bucher P, Maas H, Hammer B. Maxillofacial reconstruction with prefabricated osseous free flaps: A 3-year experience with 24 patients. Plast Reconstr Surg 2003;112:748–757.
27. Kunstfeld R, Petzelbauer P, Wickenhauser G, et al. The prefabricated scapula flap consists of syngeneic bone, connective tissue and a self-assembled epithelial coating. Plast Reconstr Surg 2001;108:1908–1914.
28. Plenk H Jr. The microscopic evaluation of hard tissue implants. In: Williams DF (ed). Techniques of Biocompatibility Testing, vol 1. Boca Raton, FL: CRC Press, 1986:35–81.
29. Hatzfeld M, Weber K. The coiled coil of in vitro assembled keratin filaments is a heterodimer of type I and type II keratins: Use of site specific mutagenesis and recombinant protein expression. J Cell Biol 1990;110:1199–1210.
30. Marx RE. Clinical application of bone biology to mandibular and maxillary reconstruction. Clin Plast Surg 1994;21:377–392.
31. Marx RE, Carlson ER, Eichstaedt RM, Schimmele SR, Strauss JE, Georgeff RN. Platelet rich plasma: Growth factor enhancement for bone grafts. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1998;85:638–646.
32. Moll R, Franke WW, Schiller DL. The catalog of human cytokeratins: Patterns of expression in normal epithelia, tumors and cultured cells. Cell 1982;31:11–24.
33. Atwood DA. Reduction of residual ridges: A major oral disease entity. J Prosthet Dent 1971;26:266–279.
34. Atwood DA. Bone loss of edentulous alveolar ridges. J Periodontol 1979;50(4):11–21.
35. Hardt N, Paulus GW. Vestibuloplasty of the maxilla with palatal split mucous membrane transplants. Technique and results [in German]. Dtsch Zahnarztl Z 1983;38:785–789.
36. Matras H. Experiences with free skin-and mucous membrane transplantations in the framework of pre-prosthetic surgery. Osterr Z Stomatol 1968;65:469–474.
37. Hjørting-Hansen E, Adawy AM, Hillerup S. Mandibular vestibulolingual sulcoplasty with free skin graft. A five-year follow-up study. J Oral Maxillofac Surg 1983;41:173–176.
38. Huybers TJM, Stoelinga PJW, de Koomen HA, Tideman H. Mandibular vestibuloplasty using a free mucosal graft. A 2-7 year evaluation. Int J Oral Surg 1985;14(1):11–15.
39. Watzek G, Hommer M, Insayif J, Kratzik I. Prosthetically indicated surgical measures—An overview [in German]. Phillip J 1991;8:159–166.
40. Lee Dellon A, Tarpley TM, Chretien PB. Histologic evaluation of intraoral skin grafts and pedicle flaps in humans. J Oral Surg 1976;34:789–794.
41. Hillerup S, Terry B. Long-term behaviour of skin and mucosal grafts in the oral cavity. In: Stoelinga PJW (ed). Proceedings, Consensus Conference: The relative roles of vestibuloplasty and ridge augmentation in the management of the atrophic mandible. Chicago: Quintessence, 1984:45–53.
42. Steinhaeuser E. Results of vestibuloplasty with free skin transplantation of the lower and upper jaw [in German]. Fortschr Kiefer Gesichtschir 1965;10:19–22.
43. Laney WR, Turlington EG, Devine KD. Grafted skin as an oral prosthesis-bearing tissue. J Prosthet Dent 1968;19(1):69–79.
44. Raschke N. Healing and reinnervation of free skin and mucosal grafts after reconstruction of the vestibulum [in German]. Zahn Mund Kieferheilkd Zentralbl 1981;69(1):18–22.
45. Hill MW, Mackenzie IC. The influence of subepithelial connective tissue on epithelial proliferation in the adult mouse. Cell Tissue Res 1989;255:179–182.
46. Boukamp P, Breitkreutz D, Stark H-J, Fusenig NE. Mesenchyme-mediated and endogenous regulation of growth and differentiation of human skin keratinocytes derived from different body sites. Differentiation 1990;44:150–161.
47. Okazaki M, Yoshimura K, Suzuki Y, Harii K. Effects of subepithelial fibroblasts on epithelial differentiation in human skin and oral mucosa: Heterotypically recombined organotypic culture model. Plast Reconstr Surg 2003;112:784–792.
48. Taylor G, Lehrer MS, Jensen PJ, Sun TT, Lavker RM. Involvement of follicular stem cells in forming not only the follicle but also the epidermis. Cell 2000;102:451–461.
49. Karring T, Lang NP, Loe H. The role of gingival connective tissue in determining epithelial differentiation. J Periodontal Res 1975;10:1–11.