A Histomorphometric Comparison of the Bone Graft–Titanium Interface Between Interpositional and Onlay/Inlay Bone Grafting Techniques

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Purpose: *To analyze the bone graft-implant interface of titanium microimplants (MIs) placed at the time of bone grafting or after a healing period of 6 months and retrieved after another 6 to 14 months of healing. Integration of MIs placed in interpositional bone grafts (IBGs) in conjunction with a Le Fort I osteotomy was compared with the integration of those placed in onlay/inlay bone grafts (OBGs).* ***Materials and Methods:*** *The severely atrophied edentulous maxillae of 23 patients (14 women, 9 men) were restored with autogenous bone grafts (either IBG [n = 8] or OBG [n = 15]) and titanium implants. Six-month periods were allowed between grafting, implant placement, and abutment connection. The bone-implant interface was studied histologically with the use of unloaded titanium MIs.* ***Results:*** *Sixty-eight MIs were either* (1) *placed simultaneously with grafting and retrieved after 6, 12, or 14 months or* (2) *placed after 6 months of healing and retrieved after another 6 to 8 months. Histomorphometry indicated equal degrees of osseointegration for the 2 intraoral reconstruction techniques when looking at bone-implant contact, bone area in threads, and newly formed bone (NFB) (Student* t *test for unpaired observations). There was a significant difference between simultaneous and delayed implant placement with respect to BIC and NFB (Student* t *test for paired observations). Three additional MIs placed in the nongrafted residual alveolar ridge and retrieved after 6 months showed significantly more bone in threads and NFB (Student* t *test for paired observations;* $P = .003$ *and* $P = .009$*, respectively) compared to MIs placed at graft placement (6 months' healing).* ***Discussion:*** *Timing of implant placement appeared more important than healing time or surgical technique. The delayed approach resulted in better implant integration, probably because of the initial revascularization of the graft.* ***Conclusions:*** *Implant integration was similar in the IBG and OBG groups. Placement of MIs after an initial healing period of 6 months resulted in better integration than placement simultaneously with grafting.* (More than 50 references) INT J ORAL MAXILLOFAC IMPLANTS 2006;21:52–62

Key words: *autogenous bone grafts, atrophic maxilla, edentulous maxilla, interpositional bone graft, microimplants, onlay/inlay bone grafting*

Loss of teeth leads to alveolar bone resorption and eventually changes in the maxillomandibular relationship.[1,2] Restoration procedures for the resorbed jaw, including bone grafts and implant-supported prostheses, require different surgical approaches depending on the severity of resorption. For the atrophic edentulous maxilla with a reversed maxillomandibular relationship and/or increased vertical distance, several authors have described a technique which includes a change in the basal relation between the maxilla and the mandible by using interpositional bone grafts after a Le Fort I osteotomy.[3–11] In situations with a normal or acceptable maxillomandibular relationship but a thin maxillary alveolar process or loss of bone height in the anterior maxilla, various onlay and inlay reconstruction techniques have been used.[12–22]

The Le Fort I osteotomy with downfracture of the maxilla is an invasive technique which can result in complications such as fracture of the maxilla,[23] severe bleeding,[24] and temporary nerve disturbances.[25–27]

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For the onlay/inlay techniques, which are less invasive, complications such as wound dehiscence and subsequently graft exposure[28] and postoperative infections[29] have been reported. Perforations of the sinus membrane normally heal without problems, but infections such as sinusitis may occur.[30]

With regard to the sequence of treatment, clinical results,[8–10,13-17,20–22,31,32] morphometric studies,[33] resonance frequency analysis,[34] and the possibility for optimal implant placement[11,35] indicate that the 2-stage procedure is the preferred treatment compared to simultaneous placement of the implants.

Revascularization is the key factor for successful incorporation and remodelling of the bone graft.[36] The revascularization process is dependent on the vascular supply in the host area,[37] and surgery should always be carried out as gently as possible to preserve the supply of blood vessels.[38,39] Knowledge of the vascular supply to the maxilla is essential when planning the surgery.[38,40-42] The ability of the bone graft to respond to the surgical trauma when a dental implant is placed will most likely influence the quality of the integration and the stability of the implant. Lundgren and associates[33] showed a higher degree of bone-implant contact for microimplants placed after 6 months of graft healing than for implants placed simultaneously with a bone-grafting procedure. These results probably reflect the degree of revascularization and consequently the potential for bone formation after implant placement. One may further speculate that the incorporation of an interpositional graft may be better because the contact area with the host bone is greater than is the case with an onlay bone graft, which adjoins soft tissues to a greater extent. However, knowledge concerning implant integration in bone augmented using different techniques is limited.

The purpose of the present study was to histomorphometrically analyze the bone graft-implant interface of titanium microimplants placed either at the time of the bone graft or after a healing period of 6 months and retrieved after another 6 to 8 months. Furthermore, the integration of microimplants placed in interpositional bone grafts after a Le Fort I osteotomy was compared with that of implants placed in onlay bone grafts.

MATERIALS AND METHODS

Microimplants

Screw-type microimplants were machined from commercially pure titanium. The implants had a 5-mm long body threaded section, which was 2 mm in diameter, and a slotted head (Fig 1). Prior to surgery the implants were ultrasonically cleaned in baths containing trichlorethylene and pure alcohol for 10 minutes in each solution and sterilized by autoclaving.

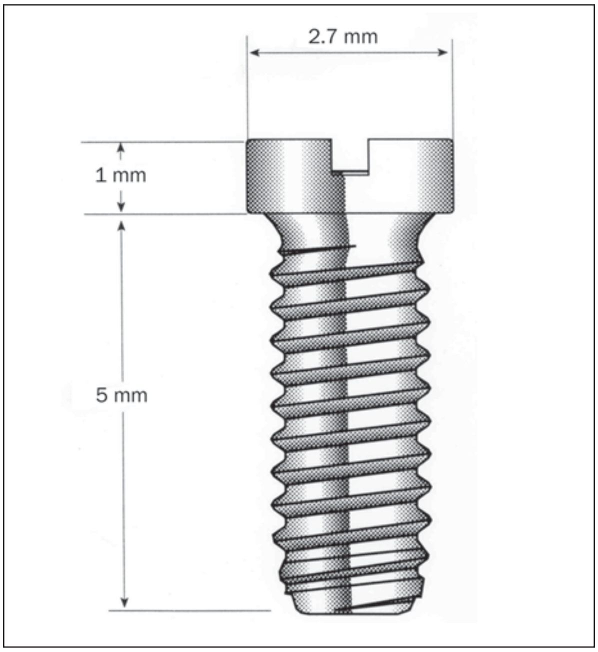
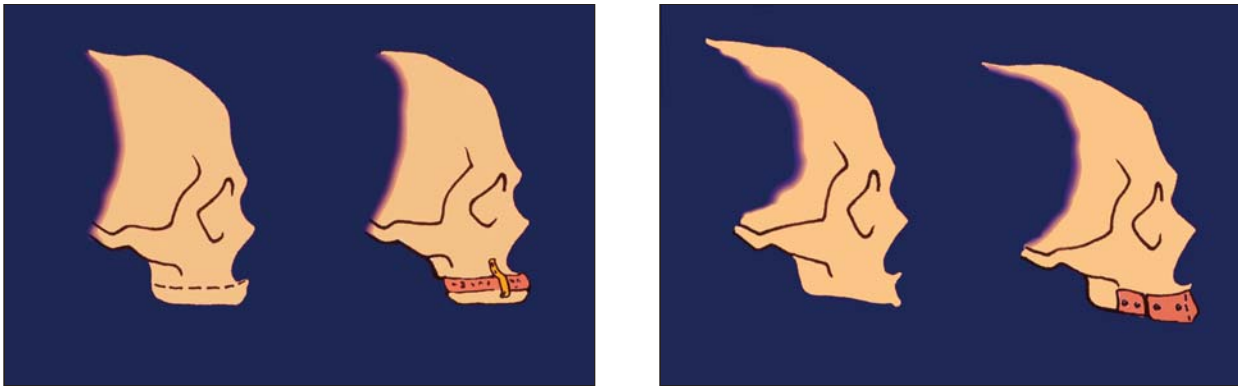


Fig 1 Sketch of the commercially pure titanium microimplant used in study.

Patients

Twenty-three patients (14 women, 9 men;) with severe atrophy in the edentulous maxilla were referred to the Department of Oral & Maxillofacial Surgery, Umeå University, Umeå, Sweden. The patients' severely resorbed edentulous maxillae were to be restored with an autogenous iliac bone graft and endosteal implants in a 2-stage procedure. The maxillae of 8 patients (4 women, 4 men; mean age, 54 years; range, 48 to 62 years) with insufficient bone volume together with a reversed maxillomandibular relation, with or without increased vertical distance, were restored using an interpositional bone graft after a Le Fort I osteotomy[9] (Fig 2a). Fifteen patients (10 women, 5 men; mean age, 56 years; range, 44 to 67 years), with a thin alveolar crest or loss of bone height in the anterior maxilla, were restored with an onlay bone graft together with a nasal floor inlay graft[16] (Fig 2b). Nine of the patients had an additional maxillary sinus floor inlay graft. The consequences of age and gender distribution between the 2 groups will be further addressed in a subsequent article with a multifactorial analysis of the bone graft. The study was approved by the regional ethics committee at the University Hospital in Umeå and was a part of a clinical prospective histologic study. All



Figs 2a and 2b A diagram of *(a)* the interpositional bone grafting technique and *(b)* the onlay bone grafting technique.

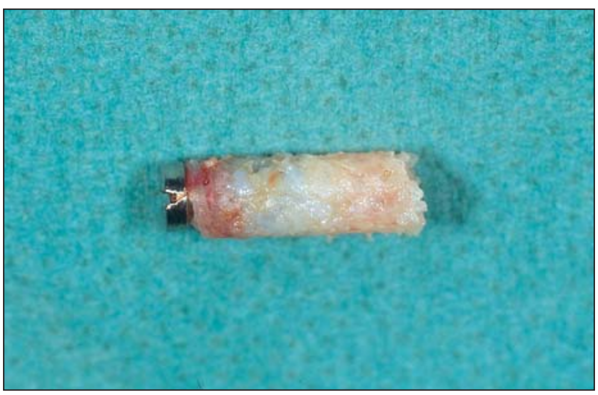


Fig 3 Specimen after retrieval with a trephine.

patients were given written information about the study, and their consent was registered in their charts.

Placement of the Microimplants and Biopsy Procedure

At the first surgery (bone grafting), a 1.6-mm twist drill was used to prepare 2 microimplant sites in grafted bone only. The microimplants, commercially pure titanium with a turned surface, were placed with a small screwdriver as in the case of self-tapping screws until the head reached the surface of the bone graft. There was no contact with the residual alveolar ridge. These implants were placed horizontally and were never intended to be loaded. In 3 patients reconstructed with interpositional bone graft, an additional microimplant was placed in the residual alveolar ridge. During drilling and implant placement there was copious irrigation with sterile saline. Good primary stability was achieved for all implants. At the time of implant placement (6 months later), 1 microimplant was retrieved together with the surrounding bone tissue using a trephine drill (inner diameter 3.1 mm), and an additional microimplant was placed in the healed graft. The microimplants placed in the residual alveolar ridge were also retrieved and served as control implants for the microimplants placed in the bone graft. The remaining 2 microimplants were retrieved at the third surgery (abutment connection) a minimum of 6 months later. In this way, 3 microimplants from each patient (apart from the first patient, who had only 2) could be analyzed histologically as representing *(1)* simultaneous placement and 6 months of healing, *(2)* simultaneous placement and 12 to 14 months of healing, and *(3)* delayed placement and 6 to 8 months of healing. A total of 68 microimplants were placed in grafted bone in 23 patients. In 3 patients, 3 additional microimplants were placed in the residual alveolar ridge and served as controls for the integration in the nongrafted alveolar crest.

Specimen Processing and Analysis

The specimens (Fig 3) were fixed by immersion in 4% buffered formalin solution, dehydrated in a graded series of ethanols, and embedded in plastic resin (Technovit A 7210 VCL; Kulzer & Co, Hanau, Germany). According to a technique described by Donath and Breuner,[43] sections were cut and ground to a thickness of approximately 10 mm by means of Exakt cutting and grinding equipment (Exakt Apparatbau, Norderstedt, Germany). The ground sections were stained with 1% toluidine blue and 1% pyronin-G. Examination, photography, and histomorphometrical measurement was carried out using a Leitz Orthoplan microscope (Wetzlar, Germany) (objectives 1.6× to 40×, with the ability to zoom in up to 2.5× when needed) equipped with a Leitz Microvid Morphometric System and connected to a personal computer (IBM, New York, NY). The measurements were performed at 6× and 10× magnification. The mineralized bone–implant contact was measured and

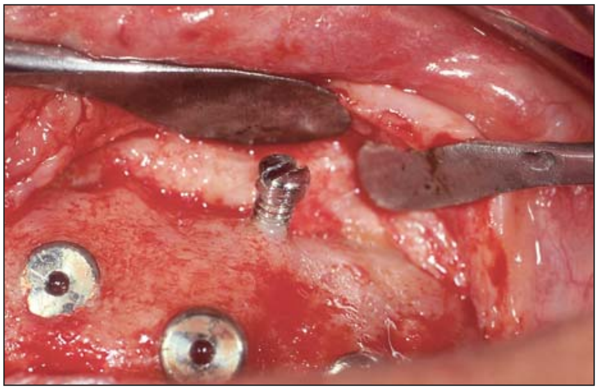


Fig 4a Clinical view of microimplant placed in bone graft with marginal bone resorption.

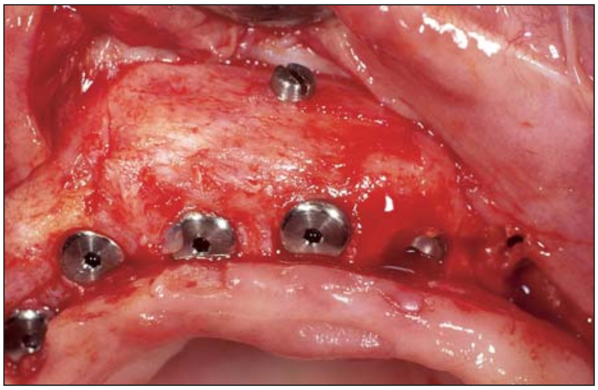


Fig 4b Clinical view of microimplant placed in bone graft with no marginal bone resorption.

expressed as percentage of the total distance from the lowest point of the implant head to the last apical thread. The bone area within the threads was calculated as the area of bone within each thread divided by the total thread area. A mean was calculated for each specimen based on measurements in all threads. Calculations were also made of new and grafted bone in the biopsies and expressed as a percentage of newly formed bone (NFB) in the biopsy area. The total bone area was calculated as the area of bone divided by the total biopsy area minus the area occupied by the implant. Mean values and SDs were calculated.

Statistics

The statistical analysis was performed using the SPSS software package (version 10.0; SPSS, Chicago, IL). The Student *t* test for paired observations was used for comparing 1-stage and delayed implant placement techniques, as well as microimplants placed in the residual alveolar crest compared to microimplants placed simultaneously with grafting and retreived after 6 months. The Student *t* test for unpaired observations was used to compare the 2 bone grafting techniques. All significance tests were 2-tailed, and a value of $P \leq .05$ was considered significant.

RESULTS

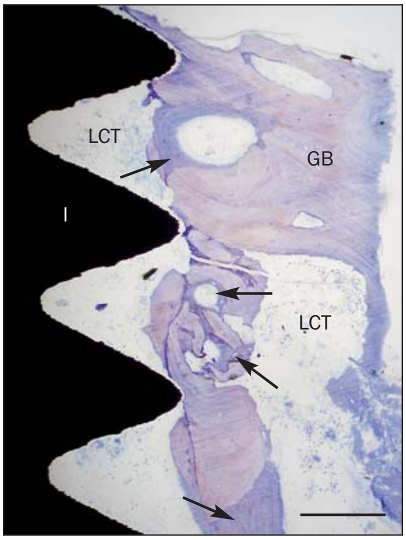
Clinical Findings

The bone grafts were successfully incorporated, and the whole treatment, including grafting, implant placement, and abutment connection, was uneventful, without any severe complications in any of the 23 patients. Sixty-five of the 68 microimplants placed in grafted bone were clinically stable when tested with a forceps. Three microimplants were damaged during retrieval or specimen processing. All 3 microimplants placed in the residual alveolar ridge were clinically stable. A few (4 to 6) of the microimplants showed severe marginal bone resorption around the head (Fig 4a); however, the majority showed no or only minor marginal bone resorption (Fig 4b). The biopsy procedure caused bleeding from the bone graft, indicating revascularization of the grafted bone.

Biopsies

All specimens contained a central section of microimplant and various amounts of bone and soft tissue. There were no apparent differences between microimplants retrieved from interpositional bone grafts and those retrieved from onlay/inlay bone grafts. However, differences could be seen between microimplants with respect to the different schedules of placement and retrieval.

The tissue around implants placed simultaneously with grafting and retrieved after 6 months (Figs 5a to 5d) had a more immature appearance than that of the other 2 groups. Grafted bone could easily be distinguished. Both resorption and formation of new bone were evident on and in the grafted bone. The implant surface was only occasionally in contact with (NFB). The soft tissue components consisted of loose connective tissue rich in vessels, sinusoids, and cells,



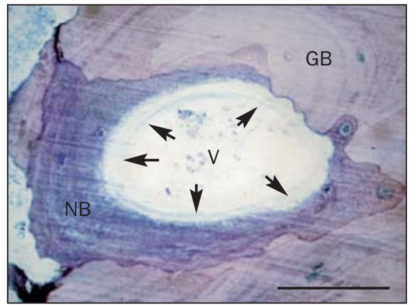
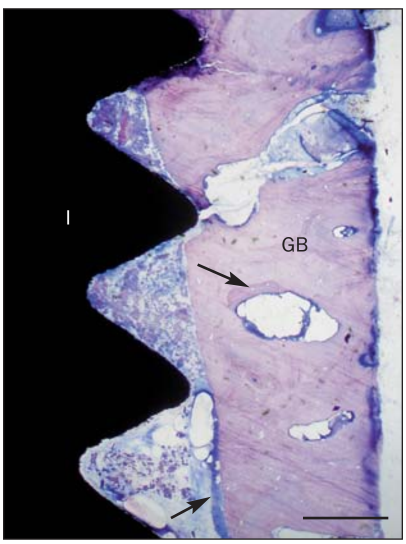


Fig 5a Light micrograph of a specimen placed simultaneously with grafting and removed after 6 months. The onlay grafting technique was used. The implant (I) was mainly in contact with loose connective tissue (LCT). Some thread tips were in contact with grafted bone (GB). New bone formation *(arrows)* is seen in conjunction with the grafted bone (toluidine blue; bar = 200 µm).

Fig 5b A higher magnification of *(a)* showing the formation of new bone (NB) following resorption of the grafted bone (GB). Bone was formed in circular lamellae typical of secondary osteons. Arrows show sites of active bone formation toward the center of the osteon, which was occupied by a vessel (V) (toluidine blue; bar = 100 µm).



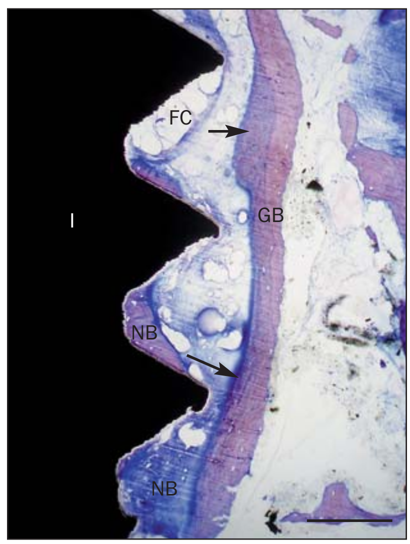


Fig 5c Light micrograph of another specimen placed simultaneously with grafting and removed after 6 months. The interpositional grafting technique was used. Mainly grafted bone (GB) is seen near the implant. Formation of new bone *(arrows)* can be seen within and on the surface of the grafted bone. The implant-tissue interface consisted of connective tissue and displaced bone fragments, probably from the drilling of the implant site (toluidine blue; bar = 200 µm).

Fig 5d A deeper area of the same specimen seen in *(c)*. A thin rim of grafted bone (GB) is seen parallel with the implant surface. New bone (NB) is seen on the grafted bone *(arrows)* and in direct contact with the implant surface. Occasional fat cells (FC) can be observed (toluidine blue; bar = 200 µm).

and the morphology resembled that of bone marrow.

The morphology of the tissue surrounding implants placed simultaneously and retrieved after 12 to 14 months (Figs 6a to 6d) resembled that of the tissue surrounding microimplants placed after a 6-month postgrafting healing period (Figs 7a to 7d). The bone had a mature appearance, with lamellar bone and secondary osteons present. Grafted bone could still be distinguished. Active bone formation could still be observed, and more bone was in contact with the implant surface.

Interpositional vs Onlay/Inlay

Specimens from patients in whom the interpositional bone grafting technique was used tended to have greater bone-implant contact, more bone area within the threads, and more NFB than specimens from patients in whom the onlay/inlay grafting technique was used for the group loaded simultaneously with grafting and given 12 to 14 months to heal and for the group where the 2-stage technique was used. However, these differences were not statistically significant. Mean values, standard deviations, and *P* values for the 2 grafting techniques are presented in Table 1.

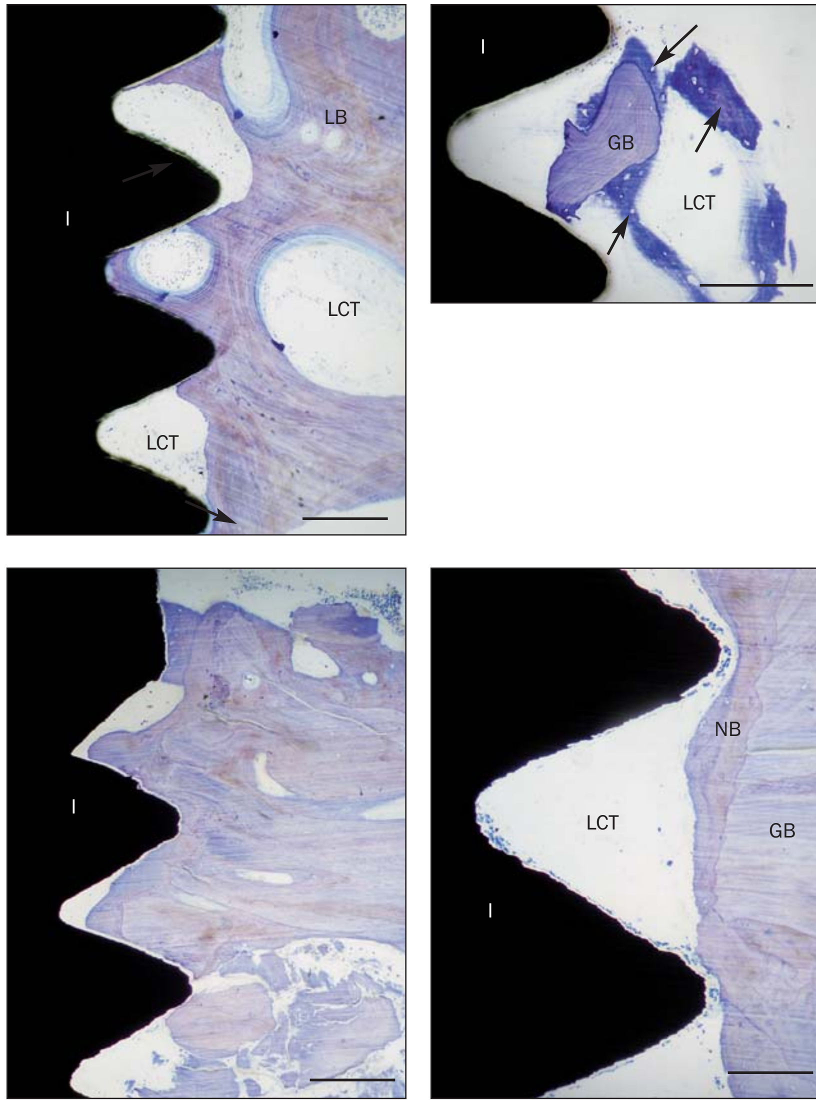


Fig 6a Light micrograph of a specimen placed simultaneously with grafting and allowed to heal for 12 months. The onlay grafting technique was used. Mature lamellar bone (LB) is seen adjacent to and in contact with the implant (I) surface. It is difficult to distinguish between grafted and newly formed bone. The nonmineralized tissue consisted of a loose connective tissue (LCT) rich with cells and vessels (toluidine blue; bar = 200 µm).

Fig 6b A higher magnification of another area of the same specimen seen in *(a)*. New bone *(arrows)* is formed at and around a piece of grafted bone (GB). LCT = loose connective tissue (toluidine blue; bar = 100 µm).

Fig 6c Light micrograph of another specimen placed simultaneously with grafting and allowed to heal for 12 months. The interpositional grafting technique was used. An admixture of grafted and newly formed bone surrounded the implant (I) (toluidine blue; bar = 200 µm).

Fig 6d A higher magnification of another area of the same specimen as in *(c)*. A loose connective tissue (LCT) is separating the implant (I) from grafted (GB) and new bone (NB) (toluidine blue; bar = 100 µm).

Simultaneous vs Delayed Placement

The degree of bone-implant contact for the 3 groups of microimplants is presented in Fig 8. There was a statistically significant difference between the delayed-technique group and group where implants were simultaneously placed and allowed 6 months of healing ($P = .05$), in favor of the delayed-technique group.

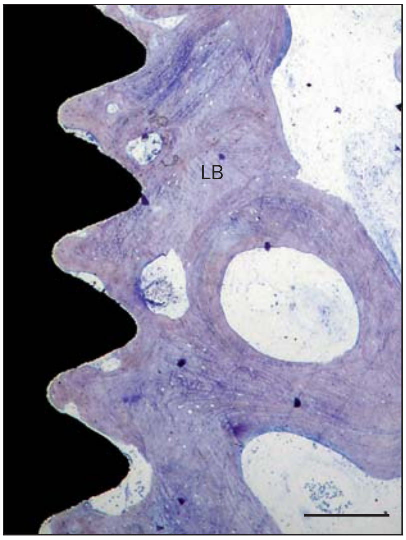
No significant differences were observed between the groups with respect to the amount of bone within the implant threads (Fig 9). When analyzing the total specimen area, microimplants placed after a delay were surrounded by significantly more new bone ($P \leq .05$), compared to simultaneously placed microimplants (Fig 10).

Implant Healing Time

Four microimplants placed in bone grafts using the simultaneous technique were retrieved after 14 months rather than 12. Another 4 microimplants placed in bone grafts using the delayed technique were retrieved after 8 months rather than 6. The decision was made to allow 2 months' prolonged healing time for these microimplants because earlier removal might have jeopardized osseointegration of the "regular" implants placed in the same patients, which had been placed with low initial stability.

Microimplants in the Nongrafted Residual Alveolar Ridge

Three microimplants placed in the residual alveolar



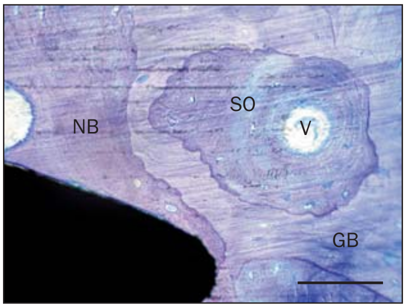


Fig 7a Light micrograph of a specimen placed 6 months after grafting and allowed to heal for 12 months. The onlay grafting technique was used. Mature lamellar bone (LB) contacted the implant to a high degree (toluidine blue; bar = 200 µm).

Fig 7b Another area of the same specimen shown in *(a)*. At a higher magnification, it is possible to distinguish between grafted (GB) and new bone (NB). A secondary osteon (SO) has been formed in the grafted bone. V = vessel (toluidine blue; bar = 100 µm).

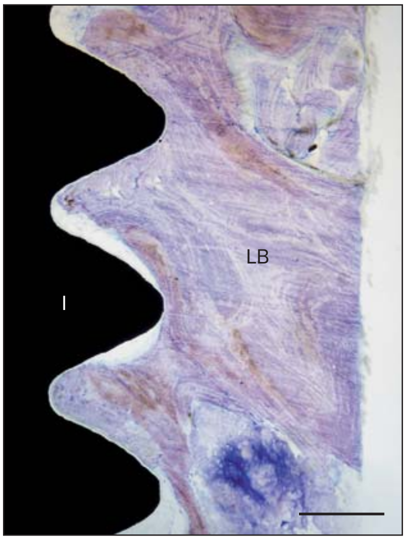


Fig 7c Light micrograph of another specimen placed 6 months after grafting and allowed to heal for 12 months. The interpositional grafting technique was used. The implant (I) was in contact with lamellar bone (LB) to a high degree. Brownish areas indicate remnants of grafted bone (toluidine blue; bar = 200 µm).

Fig 7d A higher magnification of *(c)*. The lamellar bone (LM) approached and contacted the implant (I) surface (toluidine blue; bar = 100 µm).

Table 1 Comparison Between Interpositional and Onlay/Inlay Bone Grafting Technique (Mean ± SD)

	Interpositional (n = 8)	Onlay/inlay (n = 15)	*P**
Bone-implant contact			
A	14.6 ± 8.2	20.8 ± 17.6	.270
B	28.4 ± 16.7	23.2 ± 8.8	.467
C	37.7 ± 20.5	25.2 ± 1.5	.214
Bone area within threads			
A	22.1 ± 9.2	25.2 ± 17.9	.585
B	33.5 ± 16.7	24.0 ± 9.0	.198
C	41.8 ± 22.3	28.1 ± 17.6	.221
New bone area			
A	57.5 ± 7.1	63.2 ± 9.0	.115
B	67.3 ± 9.1	60.2 ± 8.6	.143
C	75.3 ± 12.3	66.3 ± 14.3	.163

**P* values are interpositional vs onlay/inlay.
A = simultaneous load, 6-month healing; B = simultaneous load, 12–14 month healing; C = delayed load, minimum 6-month healing. "Healing" refers to the healing period between implant placement and removal.

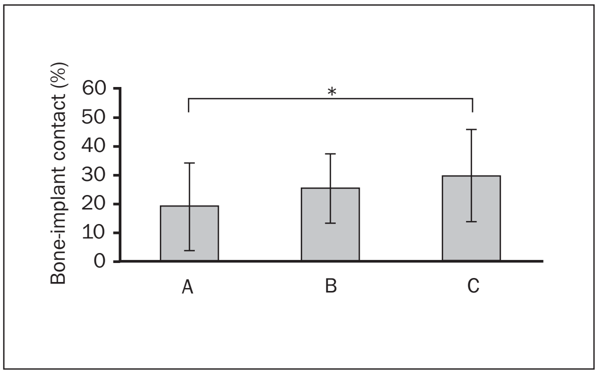


Fig 8 Results from morphometric measurements of degree of bone-implant contact. A statistically significant difference was found between implants placed simultaneously with grafting and allowed 6 months of healing and those placed 6 months after grafting. "Healing" refers to the healing period between implant placement and removal. *$P < .05$.

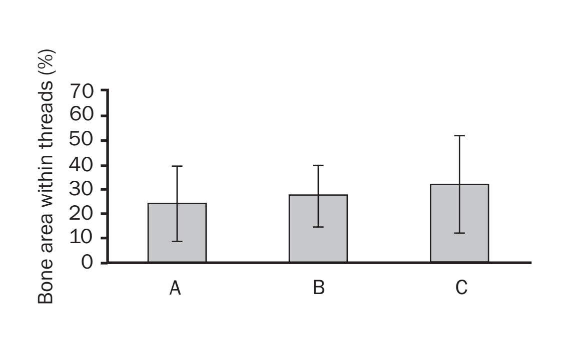


Fig 9 Results from morphometric measurements of degree of bone area within implant threads as a percentage of the total bone area. No significant differences were found between groups.

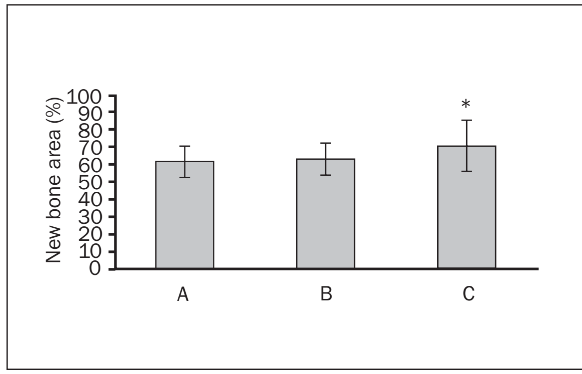


Fig 10 Results from morphometric measurements of amount of NFB in total microimplant specimen area. *$P < .05$ when the delayed technique group was compared with the other groups.

ridge and retrieved after 6 months showed significantly greater mean values for bone area within the threads (58.0% ± 13.7% versus 25.7% ± 11.0%; $P = .003$) and newly formed bone (75.0% ± 8.0% versus 56.5% ± 10.9%; $P = .009$) than the microimplants placed in interpositional bone grafts using the simultaneous technique and retrieved after 6 months from the same patients. The implants placed in the residual alveolar ridge also had greater bone-implant contact (49.3% ± 18.3% versus 21.7% ± 7.1%); however, the difference was not statistically significant ($P = .112$).

DISCUSSION

The histomorphometric results of the current study indicate equal degrees of osseointegration for the microimplants irrespective of the intraoral reconstruction technique used. When comparing the simultaneous and delayed bone-grafting techniques, the use of different implant healing times with the simultaneous technique did not result in any significant differences in bone-to-implant contact, area of bone in the threads, or amount of NFB. However, more bone-to-implant contact and NFB were seen with delayed microimplants compared with those placed simultaneously, which is in line with the findings of Lundgren and associates.[33] The findings indicate that the conditions for implant integration are improved after an initial period of healing for the bone graft. This is most probably the result of revascularization. Furthermore, delayed grafting allows the bone graft to respond to the surgical trauma; later, when implants are placed, the conditions are similar to those of normal nongrafted bone. The integration of TiO_2-blasted and turned titanium microimplants in nongrafted maxillae was reported in a histomorphometric study by Ivanoff and coworkers.[44] A crude comparison of mean values between that study and the present study shows that delayed implant placement in grafted bone results in degrees of bone-implant contact similar to or even higher than those for microimplants placed in nongrafted maxillary bone.

Implant integration was similar for both bone grafting techniques, although there was a tendency for greater mean values for the interpositional technique. The sex distribution may have had an impact on the results. However, the difference between the bone grafting techniques was nonsignificant. One conclusion to be drawn from the results may be that the onlay/inlay grafting technique should be used, as it requires less invasive surgery and thus a lower risk of complications. However, the techniques are used for different indications; neither is appropriate to all situations.

The endpoint for the resorption of the edentulous maxilla sometimes not only precludes implant placement because of limited bone volume, but can also create a reversed maxillomandibular relation or an increased vertical distance between the jaws. Correction using interpositional bone grafts and a Le Fort I osteotomy facilitates the placement of implants in favorable positions and angulations and allows the fabrication of an implant-supported prosthesis that is acceptable esthetically and phonetically.[9] Clinically, correction with the interpositional bone grafting technique is stable both vertically and horizontally,[45] probably because of the stabilization from the corticocancellous graft. Small relapses seem to have no significant impact on the final result if implants are placed at a later stage.[9,11]

Even if the implant integration process is similar between the 2 grafting techniques, as shown in the present study, the clinical implant survival rate may differ because of differences in available bone and implant lengths, as indicated in previous studies.[9,16] In these studies, more implant failures were experienced after the onlay/inlay grafting technique than after the interpositional/Le Fort I technique, probably because of the fact that shorter implants were used in the former. The volume of the bone graft itself, the degree of resorption,[9,16] and the outcome of the bone graft integration and volumetric maintenance[46] are factors that influence the bone volume available for implant placement. The mechanisms behind bone graft resorption are not clearly understood, but factors such as donor bone quality, degree of vascularization during healing, and/or local occlusal trauma to the graft probably play a role. If the resorption is pronounced, the available bone volume for implants is reduced, and accordingly the use of short implants is indicated.[16] Several authors[47–49] have reported higher failure rates with shorter implants.

Vascularization of the maxilla is complex, with blood supplied by several arteries.[38,41,50] This was exemplified by Dodson and associates,[51] who reported that ligation of the descending palatine artery did not change the maxillary gingival blood flow. Interpositional bone grafting after a Le Fort I osteotomy is likely to be more invasive with respect to the blood supply than the onlay/inlay grafting technique. This may explain why the microimplants placed simultaneously with interpositional bone grafts and removed after 6 months showed a tendency toward lower mean values than the corresponding onlay/inlay technique microimplants. The microimplants allowed 12 months of healing and those placed after initial healing of the bone grafts showed similar or higher mean values, which may indicate that the maxillary blood supply was restored after the Le Fort I osteotomy.

The biopsy procedure produced bleeding from the graft at all time points, indicating revascularization of the grafted bone. This observation corresponds with the results of Stroud and colleagues,[52] who demonstrated a hypervascular response at the 6-month healing stage. However, it is debatable whether the bleeding in itself indicates an optimal capacity for implant integration. The histomorphometric results from the microimplants in the residual alveolar crest showed higher mean values than the microimplants from the bone grafts. The results are based on only 3 patients, but the values may indicate that 6 months of healing in combination with the 1-stage technique is too short a time period for optimal bone-implant integration, even if the biopsy caused bleeding. The results for implants placed using the 1-stage technique and allowed to heal for 12 to 14 months did not differ significantly from the results obtained with a 6-month healing period; thus, perhaps even 12 months of healing is too short for optimal implant integration.

Lew and colleagues[53] reported that corticocancellous bone graft blocks developed osseointegration faster than particulated bone grafts in a canine model. One reason for the difference, according to the authors, could be that the preparation of particulated bone grafts is more traumatic than harvesting a corticocancellous bone graft block. Ozaki and Buchman[54] found in a rabbit model that cortical bone grafts will maintain their volume better than cancellous bone grafts, independent of embryogenic origin. One may speculate whether better initial stability to the host bone with cortical bone blocks is 1 reason for the difference. Gordh and Alberius[46] concluded that the importance of mono- or bicortical grafts has less impact than the relative magnitude of cortical to cancellous bone in the graft or the bone density. Experimental studies on rats[55] and dogs[56] showed that perforation of the graft as well as the recipient cortical bed improves the bone incorporation of the onlay graft. Slotte and Lundgren,[57] on the other hand, showed that there was no difference in augmented tissue volume beyond the skeletal envelope when they compared perforated and non-perforated rabbit skulls in a guided bone augmentation procedure.

Two clinical articles illustrate the importance of bone graft revascularization and incorporation for the integration of titanium implants. Nyström and colleagues[58] studied bone-implant contact 4 months after 1-stage restoration of a severely resorbed edentulous maxilla with autogenous iliac bone graft and titanium implants. The authors found only minimal bone-implant contact. Lundgren and coworkers[33] compared 1-stage and 2-stage restoration techniques and found significantly more bone-implant contact, more bone in implant threads, and greater amounts of NFB after use of the 2-stage technique. The authors attributed the better results with the 2-stage technique to the fact that the graft was able to respond to surgical trauma as the result of an initial revascularization, resulting in interfacial bone formation.

Only one section per microimplant was subjected to histomorphometric analysis. Thus only a small part of the bone-implant interface could be evaluated. Analyses of serial sections may be preferable. However, the ground sectioning technique used in the present study allows for the preparation of only 1 or 2 central sections because of the cutting and grinding. This problem in analyzing biopsies may be solved by a promising new technique described in an article by Sennerby and associates.[59] The authors presented a microtomographic technique that allows for a 3-dimensional analysis of the specimen.

CONCLUSIONS

It was concluded that implant integration in interpositional bone grafts, placed after a Le Fort I osteotomy, is similar to that in onlay/inlay bone grafts when used for restoration of the severely resorbed maxilla. Placement of implants after an initial healing period of 6 months results in better integration than implant placement simultaneous with grafting.

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