Histologic Evaluation of Brånemark Clinic Oral Implants Retrieved from Grafted Sites

Pia Bolind, DDS;* Carina B. Johansson, PhD;† Petra Johansson, Res Tech;‡
Daniel van Steenberghe, MD, PhD;§ Tomas Albrektsson, MD, PhD‖

ABSTRACT

Purpose: The aim of this report is to quantitatively and qualitatively describe the bone tissue response to Brånemark implants retrieved from grafted sites in patients.

Materials and Method: The material consists of consecutively received Brånemark implants retrieved from grafted sites. Thirty-five of these implants, retrieved from 16 patients, were suitable for the histologic evaluation of undecalcified sections in the light microscope.

Results: The unloaded implants were mainly lined with soft tissue, and sparse bone-implant contact was observed only in some sections. The loaded implants, with the exception of one implant removed due to mobility, had mature and new bone-implant contact. Resorption of graft through cutting cone structures was detected. Cement lines were found separating bone-like tissue albeit no cellular content and bone tissue with detectable osteocytes.

Conclusion: In this heterogeneous group of implants from grafted sites, the unloaded implants showed limited bone-implant contact. The autografts showed seemingly mixed viability as judged by the cell content in the osteocyte lacunae and cement lines separating areas with filled and empty lacunae.

KEY WORDS: dental implant, grafted sites, histology

Rehabilitation of completely or partially edentulous jaws with implants and prosthetic treatment has become a routine procedure. However, in patients lacking sufficient bone volume for adequate implant placement, the need to enhance bone volume has been met by applying various augmentation procedures. The use of osseointegrated implants with autogenous iliac bone grafts for jaw reconstruction was discussed by Brånemark and colleagues in the 1970s.[1] Since then, numerous articles have been published presenting various grafting procedures using different types of implants and grafting materials for oral rehabilitation.

The Retrieval Laboratory at the Department of Biomaterials/Handicap Research, Göteborg University, has received 42 Brånemark implants from grafted sites submitted over the last 11 years. This report includes all consecutively received samples of such retrieved oral implants.

The aim of the present report is to quantitatively and qualitatively describe the bone tissue response to Brånemark implants retrieved from grafted sites in patients.

MATERIALS AND METHODS

The materials consist of consecutively received oral implants retrieved from grafted sites and related patient

*Department of Biomaterials/Handicap Research, Institute for Surgical Sciences, The Sahlgrenska Academy at Göteborg University, Göteborg, Sweden; †associate professor, Department of Biomaterials/Handicap Research, Institute for Surgical Sciences, The Sahlgrenska Academy at Göteborg University; professor, Department of Technology, Örebro University, Örebro, Sweden; ‡laboratory technician, Department of Biomaterials/Handicap Research, Institute for Surgical Sciences, The Sahlgrenska Academy at Göteborg University, Göteborg, Sweden; §professor and holder of P-I Brånemark Chair in Osseointegration, Department of Periodontology, Catholic University Leuven, Leuven, Belgium; ‖professor, Department of Biomaterials/Handicap Research, Institute for Surgical Sciences, The Sahlgrenska Academy at Göteborg University, Göteborg, Sweden

Reprint requests: Dr. Pia Bolind, Department of Biomaterials/Handicap Research, Institute for Surgical Sciences, The Sahlgrenska Academy at Göteborg University, Box 412 SE 405 30 Göteborg, Sweden

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data. Altogether, 42 Brånemark implants (Nobel Biocare AB, Göteborg, Sweden) were retrieved from 19 patients. The screw-shaped implants were turned and made of commercially pure titanium. In this material, the designs were standard, self-tapping, and conical, that is, an implant with a conical neck and diameters of 3.75 and 4 mm.

On arrival at the laboratory, 7 of the 42 implants, retrieved from three patients, were lacking tissue on the implant surface and are therefore not included in the histologic evaluations.

For the 35 implants subjected to histologic evaluation according to the methods presented herein, the bone tissue response was quantitatively evaluated for 20 implants. The remaining 15 implants were either unloaded with a limited amount of tissue response following placement ($n = 11$) or with no bone-implant contact present ($n = 3$) or had been damaged during the removal procedure, making reliable calculations of bone-implant contact impossible ($n = 1$). However, all implants were evaluated qualitatively.

The 35 implants were retrieved from 16 patients; the gender was known for 12 of them (5 males and 7 females). Patient age at the time of implant removal was reported for six of the patients and ranged from 53 to 60 years. In 10 patients, the type of graft was known, with 7 autogenous grafts all harvested from the hip and 3 allogenous grafts consisting of demineralized freeze-dried bone. The grafts were located in the maxilla in six patients and in the mandible in five patients. For the remaining five patients, there was no information on the location. At the time of removal, the implants had been in situ from 1 to 72 months. Sixteen implants in five patients are known to have been loaded. In four patients with 12 implants, the loading time was specified and ranged from 15 to 60 months.

The clinicians' stated reason for removal of the 35 implants subjected to histologic evaluation varied but included patient death ($n = 14$), exposed threads ($n = 4$), pain ($n = 1$), infection ($n = 1$), mobility ($n = 6$), malpositioned implant ($n = 2$), loss of the entire graft ($n = 1$), implant fracture ($n = 1$), inadequate patient adaptation ($n = 3$), and unknown ($n = 2$). Implant- and patient-related data are presented in detail in Tables 1 to 3.

At the time of removal, the implants were immersed in 4% neutral buffered formaldehyde for fixation and transported to the Department of Biomaterials/Handicap Research for further preparation. Following fixation, the samples were dehydrated in solutions with increasing concentration of ethanol (70%-absolute) and pre-infiltrated in diluted resin and thereafter infiltrated in pure resin by stirring under vacuum conditions. Finally, the samples were embedded in either LR White resin (London Resin Co Ltd, Berkshire, UK) or Technovit 7200 VLC/light curing resin (Kulzer, Germany). With EXAKT® sawing and grinding equipment (Apparatebau GmbH & Co., Norderstedt, Germany), the cured specimens were divided at the midsection along the long axis of the implant. The surfaces were evenly ground, and Plexiglass of known thickness was glued to the surface

TABLE 1 Unloaded Implants

Age	Gender	Reason for Removal	Graft	Location	Time in Place (mo)
53	M	Postmortem	Hip graft w/ simul impl plac	Mx	4
		Postmortem	Hip graft w/ simul impl plac	Mx	4
		Postmortem	Hip graft w/ simul impl plac	Mx	4
		Postmortem	Hip graft w/ simul impl plac	Mx	4
		Postmortem	Hip graft w/ simul impl plac	Mx	4
		Postmortem	Hip graft w/ simul impl plac	Mx	4
—	—		Autogenous	Md	
—	F				1
—	F	Exposed threads	Demineralized cortical bone part 5 m prior to impl plac	Mx	1.5
—	F	Mobile	Graft w/ simul impl plac		15
—	F	Mobile	Hip graft w/ simul impl plac		

Impl plac = implant placement; Md = mandible; Mx = maxilla; simul impl plac = simultaneous implant placement.

TABLE 2 Loaded Implants

Age	Gender	Reason for Removal	Graft	Location	Time in Place (mo)	Loading (mo)	% BMC 3 Best Consecutive Threads	% Bone Area 3 Best Consecutive Threads
60	M	Mobile	Graft w/ simul impl plac		11	2	—	—
		Mobile	Graft w/ simul impl plac		11	2	49 (2*)	—
		Mobile	Graft w/ simul impl plac		11	2	—	—
56	F	Inad pat adap		Mx	>60	60	78	85
		Inad pat adap		Mx	>60	60	—	—
		Inad pat adap		Mx	>60	60	70	57
		Mobile	Graft w/ simul impl plac		11	2	—	—
—	M	Postmortem	Graft w/ simul impl plac	Md	60	54	93	94
		Postmortem	Graft w/ simul impl plac	Md	60	54	96	95
		Postmortem	Graft w/ simul impl plac	Md	60	54	82	92
58	—	Postmortem	Hip graft 2 y prior to impl plac	Md	23	15	75	90
		Postmortem	Hip graft 2 y prior to impl plac	Md	23	15	51	88
		Postmortem	Hip graft 2 y prior to impl plac	Md	23	15	85	91
		Postmortem	Hip graft 2 y prior to impl plac	Md	23	15	91	90
		Postmortem	Hip graft 2 y prior to impl plac	Md	23	15	84	92
—	—	Fracture	FD regen b w/ simul impl plac	Mx	45	38	86	93

BMC = bone-metal contact; DFDB = demineralized-freeze-dried bone; Inad pat adap = inadequate patient adaptation; Md = mandible; Mx = maxilla; regen b = regenerated bone; simul impl plac = simultaneous implant placement.
*Number of evaluated threads when <3 within brackets.

of the sample. Initially, a thick section, 150 to 200 µm, was sawn from the samples. The sections were ground to a final thickness of about 10 µm.[2] Routinely, the sections were stained in toluidine blue mixed with pyronin G. Preparation and staining techniques followed the recommendations of Donath and Breuner.[3,4] These procedures are routinely carried out for all retrieved human samples at the Department of Biomaterials/Handicap Research.

The undecalcified and histologically stained sections were quantitatively and qualitatively evaluated in a light microscope. The evaluations were performed in

TABLE 3 Implants with No Information Regarding Loading

Age	Gender	Reason for Removal	Graft	Location	Time in Place (mo)	% BMC 3 Best Consecutive Threads	% Bone Area 3 Best Consecutive Threads
—	F	Exposed threads	Hip graft w/ simul impl plac	Md	21	86	92
		Exposed threads	Hip graft w/ simul impl plac	Md	21	85	91
		Exposed threads	Hip graft w/ simul impl plac	Md	21	57	81
53	M	Fistula + malalignment	Hip graft (reconstructed Md)	Md	24	67	95
		Fistula + malalignment	Hip graft (reconstructed Md)	Md	24	59	—
57	F	Pain	Hip graft w/ simul impl plac		40	89	96
—	M	Loss of graft	DFDB	Mx	7	31	51
—	—	Infection	Hip graft w/ simul impl plac	Mx	72	—	84

BMC = bone-metal contact; DFDB = demineralized-freeze-dried bone; Md = mandible; Mx = maxilla; simul impl plac = simultaneous implant placement.

an Aristoplan® light microscope (Ernst Leitz GmbH, Wetzlar, Germany) equipped with a Microvid® unit, connected to a personal computer and a computer mouse. The quantitative analyses were performed directly in the eyepieces of the microcope with an objective lens of ×10 and zoom (up to ×2.5) when needed.

The entire thread length was outlined and then the bone-contacting lengths were outlined; the bone-contacting lengths were divided by the thread length to calculate the percentage of bone-metal contact. Bone area was measured by first outlining the total area bounded by the thread and then marking the total area occupied by bone inside the thread; the percentage of bone area inside the thread was calculated by dividing the area of bone inside the thread by the total area of bone bounded by the thread. All threads on both sides were measured, and a mean value for the three best consecutive threads was calculated per implant for both bone-implant contact and bone area within the thread. Threads available for measurement varied from one implant to another but fell within the range of 2 to 30 threads.

Qualitative analyses were performed with objectives from ×1.2 to ×40 and zooming, giving a magnification range of ×400 to ×800.

RESULTS

Unloaded Implants

In two of the six patients with stated unloaded implants, one implant was claimed to be mobile in each patient. The implants were placed simultaneously with the grafts. One of the grafts was specified as autogenous, but the implant positions were unknown. There was no bone-implant contact in the sections from the implants. Soft tissue lined the entire circumference of the implants. Due to overstained sections, identification of cells was difficult. In the apical hole of the implant, pieces of bone entirely surrounded by soft tissue were visible. In sections from one of the samples, osteocyte lacunae with and without cells were visible. In cases of empty lacunae, the bone pieces were surrounded by a thick (100 µm) soft tissue capsule.

Two other unloaded implants retrieved from two patients had no claimed reason for removal or information of the grafts used. The position was specified as the posterior mandible for one of the implants. In the section from the latter implant, it seemed as if the entire graft was lost, together with the implant (Figure 1). The implant was partly separated from the bone tissue with a thin line of soft tissue. The upper coronal part of the grafted bone (cortical layer) was about 3 mm thick. In this cortical layer, empty osteocyte lacunae and osteocytes with pychnotic nuclei were detected. Cutting cone–like structures in the direction toward the implant were observed. A high amount of osteoclasts could be observed in the frontline of these structures. The midpart of the graft revealed a great amount of inflammatory cells, that is, macrophages and plasma cells. The lower part of the graft contained more bone trabeculae. Both resorptive and osteoid-like areas lacking a seam of osteoblasts were found in the trabecular bone. In the most apical region, thin bone trabeculae were found lined with areas of woven, immature bone. The section from the mandibular implant had a similar appearance in the microscope. However, in this section, only a limited amount of tissue surrounded the implant.

Figure 1 Retrieved implant from a grafted site. Time in situ was 1 month. Implant location and reason for removal were not disclosed. Magnification = implant diameter 3.75 mm.

A fifth unloaded implant was removed due to exposed threads. This implant had been placed in a maxilla augmented with an allograft 5 months prior to implant placement. At placement, a minor dehiscence (2 mm) was covered with the same allograft material. The implant was removed 1.5 months postplacement. Less than half of the implant length was located in bone. In the soft tissue coronal to the bone, few inflammatory cells and a high amount of vessels close to the implant surface were observed. In the coronal bone tissue, bone surfaces lined with osteoid-like tissue, but no osteoblast rims could be observed. However, osteoid rims could be

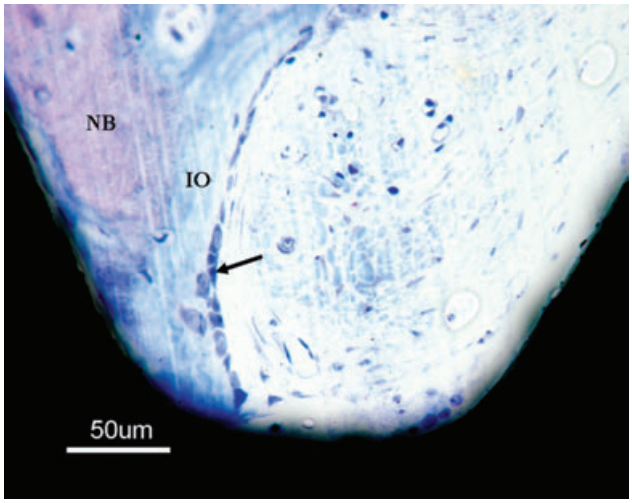

Figure 2 Implant retrieved from a grafted maxilla owing to exposed threads. Time in situ was 1.5 months. Ongoing bone apposition with the presence of osteoblasts (*arrow*) and osteoid (OI). Newly formed bone tissue can be observed (NB).

clearly detected in the more apical threaded area (Figure 2). Areas with a structure-like woven bone when observed in polarized light were found internalized in normal bone. These areas could be interpreted as remnants from the graft material. A high amount of blood vessels and cells with granules was detected in the soft tissue of this region.

The remaining six unloaded implants were retrieved from a postmortem case 4 months following simultaneous placement with an autogenous graft in the maxilla. In the sections from the implants, minimal bone-implant contact was present. Bone resorption could be detected around the marginal aspect of the implants. In one of the sections, there was a soft tissue zone in the midregion of the implant separating the upper compact bone layer from the trabecular bone in the lower part. This soft tissue contained a high amount of blood vessels and a few small bone pieces partly lined with an osteoid-like rim. Osteoblasts could not be detected. This zone, presumably, represented the borderline between the grafted and original maxillary bone. In all sections, the original bone demonstrated an ongoing resorption and apposition without signs of an inflammatory reaction. In the grafted bone, cutting cone–like structures were detected. There were signs of resorption and an inflammatory reaction but also some areas with new bone formation. Cement lines separating bone-like tissue with no cellular content and bone tissue with detectable osteocytes were present. A histologic evaluation of these implants has been reported by Nyström and colleagues[5]; however, for the results presented here, the sections have been reevaluated.

Loaded Implants

In two of the six patients with reported loaded implants, three and five implants, respectively, were retrieved postmortem. The three implants retrieved from one of the patients were placed simultaneously with an unspecified graft in the mandible. The implants had been in situ for 5 years and loaded for 4.5 years at the time of removal. Twenty-five to 50% of the coronal aspect of the implants was above the first bone-implant contact. Inflammatory cells were visible in the soft tissue coronal to the bone. Bone-implant contact was mainly mature, with haversian systems close to the implant surface. Nerve bundles were identified in both the apical region located in soft tissue and in the direct vicinity of the four to five most apical threads. At a distance from the implant, areas in the bone appeared to be remnants from the graft, as judged by the structure when observed with the aid of polarizing filters. In these areas, bone remodeling units were observed. Cement lines in various directions were detected. Bone remodeling units in the bone were found to be larger in size and greater in distance to the implant compared with the close proximity of the implant surface. The calculation of a mean value for the bone-implant contact and bone area within the threads for the three best consecutive threads of the implants was 90% and 94%, respectively.

Prior to grafting, the second patient with five retrieved implants had received radiation therapy. The autogenous bone graft in the mandible was placed 2 years prior to the implants. The time in situ for the implants at removal was 23 months, with a loading time of 15 months. The most coronal bone-implant contact for the implants was located from the first to the seventh thread. All implants, from 20 to 50% of the implant length, were located with their apical portion in the soft tissue. The soft tissue coronal to the first bone-implant contact contained inflammatory cells. There was an ongoing resorption and apposition in the bone tissue, and mature lamellar bone was found in implant contact. Bone condensation was observed at the bone-implant interface. In the trabeculae bone, distinctly stained areas containing osteocytes larger in size compared with the osteocytes in the surrounding bone tissue were detected. The calculation of a mean value for the bone-implant contact and bone area within the threads for the three

best consecutive threads of the implants was 77% and 90%, respectively.

Inadequate patient adaptation of one patient was the reason for removal of three implants in the maxilla. The implants had been loaded for approximately 5 years. There was no information on the type of graft provided for this patient. The most coronal bone-implant contact was located at the level of the first thread. The soft tissue coronal to the first bone contact, present in section from one of the implants, contained few cells. Mature and newly formed bone was found in implant contact. Lamellar structures in different directions were visible in the bone, which could be interpreted as remnants from the graft. Inflammatory cells were present in soft tissue areas within the bone, and vessels were found in close proximity to the implant surface. Quantified evaluation was possible for two of the implants. The calculation of a mean value for the bone-implant contact and bone area within the threads for the three best consecutive threads of the implants was 74% and 71%, respectively.

Four implants in one patient were removed due to mobility postloading. The implants placed simultaneously with the graft had been in situ for 11 months, with no specified position and loading time. Information on graft material is missing. The implants were mainly in soft tissue contact, with only sparse bone-implant contact in the section from one of the implants. Proliferation of the epithelium and an inflammatory cell infiltrate in the underlying soft tissue were observed. The bone was mainly under resorption. Fragments of lamellar bone with empty osteocyte lacunae were separated with cement lines from bone tissue with detectable osteocytes. Calculation of bone-implant contact was possible only in two threads from one of the implants.

A single implant in one patient was removed due to fracture 45 months following placement. The implant was placed simultaneously with an allograft in the maxilla and had been loaded for 38 months. A high degree of bone-implant contact and bone fill of the threads was observed (Figure 3) but with many empty lacunae in the bone. More resorption than apposition of the bone with a high amount of inflammatory cells in resorption cavities was seen in the section (Figure 4). The calculation of a mean value for the bone-implant contact and bone area within the threads for the three best consecutive threads of the implant was 86% and 93%, respectively.

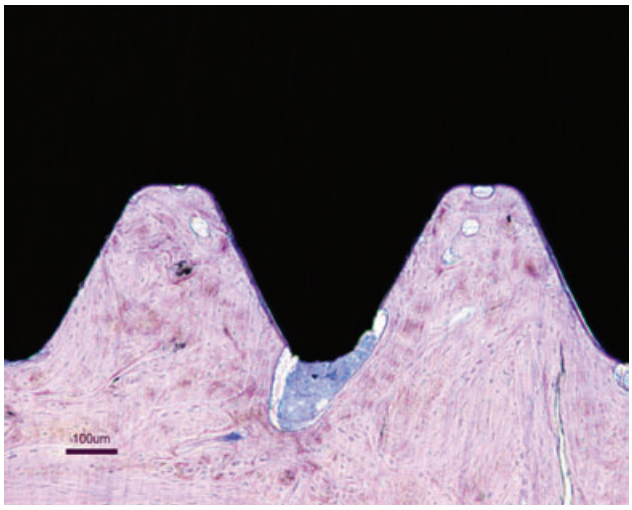

Figure 3 Implant retrieved from a grafted maxilla owing to mechanical failure. Time in situ was 45 months. A high degree of bone-implant contact and bone fill of the threads.

Implants with No Information Regarding Loading

Three implants in one patient were removed due to exposed threads. The implants were placed simultaneously with an autogenous graft in the mandible 21 months prior to retrieval. Less than half of the implant length was in bone tissue. Mainly mature bone was found in implant contact with blood vessels close to the implant surface. In general, more resorption than apposition was seen in the bone. In the section from one of the implants, areas in the bone tissue were stained differently, which might be interpreted as grafted bone being incorporated into original newly formed bone. The calculation of a mean value for the bone-implant contact and bone area within the threads for the three best consecutive threads of the implants was 76% and 88%, respectively.

Two implants were retrieved from one patient due to malposition and fistula 24 months following placement. The implants had been placed in an autogenous graft used to reconstruct the mandible following a resection. Inflammatory cells were detected in the coronal soft tissue. The first bone-implant contact was at the level of the first thread with mainly lamellar bone in implant contact. No haversian systems were found, but there were many remodeling cavities. More resorption than apposition was seen in the bone. Areas with a foamy appearance in the soft tissue lining the bone were

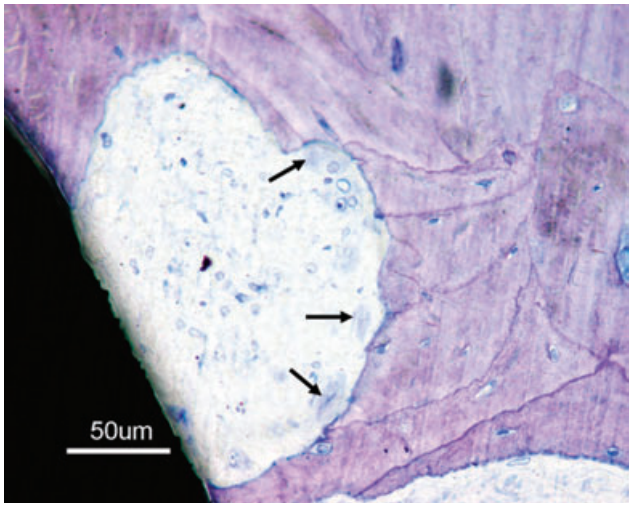

Figure 4 Resorption cavity with osteoclasts (*arrows*) on the bone surface (same specimen as in Figure 3).

found in the section from one of the implants that could be interpreted as necrotic fat cells. A high amount of blood vessels was observed at the implant-tissue interface. The calculation of a mean value for the bone-implant contact in the three best consecutive threads was possible in sections from both implants, resulting in 63%. However, calculation of bone area within the threads for the three best consecutive threads could be performed only in a section from one of the implants, with the result of 95%.

One implant in another patient was removed due to chronic pain 40 months following placement. The implant was placed simultaneously with an autogenous graft without the specified position of the implant. The coronal bone-implant contact was at the fourth thread. Mature bone with a lamellar structure in different directions gave the impression of grafted bone incorporated in the original bone formed post–implant placement. More resorption than apposition was observed in the bone. The calculation of a mean value for the bone-implant contact and bone area within the threads for the three best consecutive threads of the implant was 89% and 96%, respectively.

One implant from one patient was claimed to be lost together with the allograft in the maxilla. There is no information on the time in situ for the implant. The first coronal bone-implant contact was at the level from the second to the fourth threads. A limited amount of bone-implant contact was found. The bone comprised areas with large empty lacunae surrounding areas of bone tissue with cells. With the aid of polarizing filters, different directions of the collagen fibers could be detected for the areas with and without cell contect. In the apical region, a high degree of bone resorption and no bone remodeling units were found. In the soft tissue cavities in the bone, blood vessels, inflammatory cells, macrophages, and plasma cells were observed. Stained areas with a configuration like bristle (possibly bacteria; K. Donath personal communication, 2004) were found on the surface of the bone with empty lacunae (Figure 5). The calculation of a mean value for the bone-implant contact and bone area within the threads for the three best consecutive threads of the implant was 31% and 51%, respectively.

Infection was the reason for removal of one implant in one patient. The implant was, simultaneously with an autogenous graft in the maxilla, placed 72 months prior to removal. Approximately, a bit more than half of the implant length was located in bone. The soft tissue coronal to the bone contained few vessels and cells. The interface was lined with a thin blue-stained film with an outer capsule-like formation in contact with the surrounding bone. In the bone tissue, lighter-stained areas with empty osteocyte lacunae were separated by cement lines from darker-stained areas with visible osteocytes. Bone remodeling cavities, lacking cell content, were detected in the bone tissue with both the lighter and darker stainings. The calculation of a mean value for the

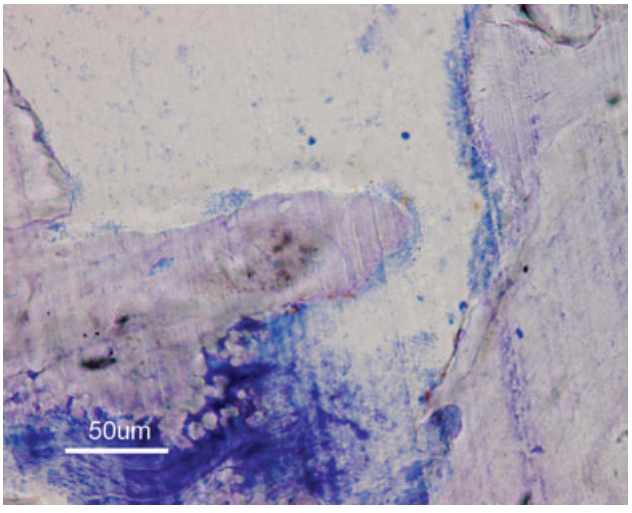

Figure 5 Implant retrieved from a grafted maxilla owing to loss of the entire graft. Time in situ was not disclosed. Blue-stained, bristle-like areas on the bone surface indicating possible bacteria.

bone area within the threads of the three best consecutive threads of the implant was 84%.

DISCUSSION

The fate of the autologous bone graft has been discussed since the late 1800s.[6,7] Ollier believed that the outcome of bone transplantations depended mainly on graft factors,[6] a statement that was criticized by Barth.[7] For many decades, the graft was regarded mainly as a scaffold that allowed bone ingrowth, a belief that inspired Orell in the 1930s to develop devitalized, heterologous bone grafts.[8,9] The first investigations on bone induction were published around this time.[10–12] However, on the basis of vast clinical experience during the Second World War, opinions changed toward a clear understanding of the importance of a potentially viable and revascularized bone graft.[13] The positive contribution not only of graft matrix but also of graft cells was stressed.[14–16] Still to this day, some controversy persists, indicated by the fact that this article reports on submitted autografts as well as submitted allografts.

Large bone grafts, irrespective of an allogenic or autogenic origin, were reported with failure rates of about 40% during the 1960s and 1970s.[15,17] However, in a review published in 1995,[18] reconstructive procedures with endosseous implants in grafted bone showed a somewhat better outcome, ranging from 63 to 100% success, at least in short-term follow-up studies. A 10-year evaluation of severly resorbed maxillae treated with simultaneous placement of autogenous bone grafts and implants demonstrated an implant success rate of 95% in nonsmokers. However, patients with congenital defects or who had undergone radiotherapy were deceptive.[19] A published review with a focus on Brånemark implants in grafted bone found a 14.9% prevalence of failed implants.[20] In the maxilla, onlay and inlay grafting procedures resulted in higher implant failures than did sinus and nasal lift procedures.[20]

Our material on retrieved implants from grafted sites constitutes a heterogeneous group with regard to the type of grafting material, time of implant placement in relation to the actual grafting procedure, time in situ, and loading time for the implants. In addition, all grafting procedures in the present study were performed between the mid-1980s and early 1990s. Indeed, grafting procedures in combination with implant treatment have been a growing treatment modality during the last few years, and new surgical techniques have been introduced.[21] Thus, our retrieved material originates from an earlier time before novel surgical procedures had been fully developed. Furthermore, owing to the nature of a retrieval bank, we have received submitted material from many clinicians from various parts of the world. Hence, our material is not uniform, but it does represent consecutively received samples with no preselection at our end.

Other reports on histologic evaluations of retrieved standard-size oral implants in grafted bone are rare. Piatelli and colleagues and Dattilo and colleagues reported on mandibular reconstructions with, respectively, nonvascularized and vascularized grafts harvested from the iliac crest.[22,23] In the nonvascularized grafts, implants were placed at 8 months following the grafting procedure and removed 15 months later with a loading time of 10 months.[22] Implant retrieval was done because of difficulties in maintaining adequate hygiene around the implants and for psychological reasons. Histologic examinations revealed mature bone in close contact with the implant surface, not really differing from ordinary, nongrafted implants. The four hydroxyapatite (HA)-coated implants retrieved from the vascularized graft[23] were placed 6 months after the grafting procedure and were retrieved 8 months later owing to the recurrence of a squamous cell carcinoma in the grafted region. Again, the authors reported a similar histology, with lamellar bone bordering the implant, as would have been expected in a nongrafted site.

Our data from five patients with retrieved nonvascularized grafted mandibles with 14 implants in total concur with the findings in the previously discussed report.[22] However, we did note some signs of a dominating bone resorption in the sections from the 14 implants. They had been in situ for 21 to 60 months and were removed postmortem ($n = 8$) or due to exposed implant threads and fistula ($n = 5$); for one implant, the reason for removal was not disclosed.

In the case of grafted maxillary bone with implants, we found four articles in the literature.[24–27] In one of those articles, two unloaded maxillary implants were removed postmortem from a bilateral sinus augmentation case in which surgical reconstruction and implant placement had occurred 8 months previously.[24] A bony interface was found around one implant in this case where the graft consisted of a mix of demineralized cortical bone powder and potentially resorbable HA. Another case reported histologic findings from two

loaded maxillary implants retrieved for psychological reasons.[25] The graft material in this case was a combination of OsteoGraf/N700 (CeraMed Dental, Lakewood, CO) (75%) and freeze-dried demineralized bone (25%), and implants had been placed simultaneously with antral augmentation 30 months before retrieval. Implant loading time was 24 months. Dense lamellar bone was found bordering the titanium implants. The OsteoGraf/N700 partly remained as graft particles surrounded by newly formed bone. Yet another study reported histologic findings of six implants, in situ for 37 months and loaded for 24 months, retrieved together with autogenous iliac crest bone used for sinus floor augmentation.[26] The graft had been placed 4 months prior to implant placement. Again, substantial bone-implant contact (90.4–99.8%) was noted, as were secondary osteons. Finally, another report of a HA graft used for subantral augmentation was removed owing to substantial resorption together with a HA-coated implant after 12 years in situ.[26] The bone-implant contact was 73.4%, and residual graft particles were observed. The HA implant coating was not resorbed.[27]

In our retrieved maxillary cases, autogenous bone was used in two patients, whereas allografts had been preferred in three cases, and in one further case, the origin of the graft was not disclosed. Our unloaded implants were retrieved postmortem ($n = 6$) and due to exposed threads ($n = 1$), with a time in situ of 1 to 4 months. We found limited bone-implant contact in these short-term cases. The loaded implants in this study had a reported loading time from 38 to 60 months. They were retrieved owing to inadequate patient adaptation ($n = 3$) and implant fracture ($n = 1$). We found 74 to 86% bone-implant contact for these implants.

In this article, we have reported on autografts of seemingly mixed viability consisting of bone with filled osteocyte lacunae separated by cement lines from what appears to be dead bone tissue elements with no cellular contents in the lacunae. Indeed, such grafts with mixed viability have commonly been reported in the literature.[13,28,29] Having said this, published evidence points to the fact that so-called filled and empty osteocyte lacunae are poor indicators of graft viability or death.[30] These findings may be, and largely depend on, sectioning artifacts. However, when, as in our case, we have cement lines separating areas with filled and empty lacunae, there is a control against artifacts in the same section. We strongly believe that such findings point to the differences in graft viability at some time, even if we cannot prove that the bone with filled lacunae was alive at the very time of harvesting the grafts.

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