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Measurement of Bone Metal Contact (BMC) in Retrieved Maxillofacial Osseointegrated Implants

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Eighteen screw-shaped extraoral osseointegrated implants retrieved from 10 patients were analysed by microradiography. Retrieved implants were trephined with a border of surrounding bone, fixed, embedded in epon plastic, ground and processed for microradiography. The reasons for retrieval were unexplained pain ($n = 4$), inability to cope with the implants ($n = 2$), fracture of central screw ($n = 2$), skin penetration problems ($n = 1$) and trauma ($n = 1$). The study group comprised six males and four females with a mean age of 53.4 years (range: 9–81 years). All implants were clinically stable at the time of removal, and mean osseointegration time was 3 years (range: 1–5 years). Six implants were removed from the temporal bone, five from the frontal bone and seven from the maxilla. Bone metal contact was estimated to vary between 27% and 83%. Bone metal contact was lower in the frontal bone compared to the temporal bone or maxilla, and was further reduced after preoperative irradiation. Longer osseointegration time increased bone metal contact, as did increased age up to 60 years. It is concluded that extraoral osseointegrated implants in humans may integrate morphologically as well as clinically. By microradiography it was possible to define bone metal contact in the region of implant installation. *Key words*: *age*, *irradiation*, *maxillofacial bones*, *microradiography*, *morphology*, *osseointegration*, *retrieved implants*.

INTRODUCTION

So-called "osseointegrated implants" were originally developed to be used in the oral cavity (1). Since 1977, these have also been used in the maxillofacial region (2). Extraoral osseointegrated implants have mainly been used to supply patients with bone-anchored hearing aids (3). The second most common application is to correct defects in the maxillofacial region by bone-anchored epistheses (4). Long-term statistics show good potentiality for osseointegrated implants to integrate and survive for decades (5). Nevertheless, there are clinical reports showing implant failures over time (6). Higher failure rates are especially reported after pre-implant radiotherapy (7). In the younger patient population, there are also reports of higher implant failure rates (8).

The morphological examination of osseointegrated implants retrieved from humans is important to establish the causal determinants of implant failure, and to compare and validate the results obtained from animal studies. There are some morphological studies of osseointegrated implants retrieved from the oral cavity. To date, other than case reports, only one histological study has been conducted on retrieved extraoral osseointegrated implants (9). To obtain more detailed knowledge about the osseointegration process, it seems valuable to analyse morphologically the bone implant region in implants that have been osseointegrated clinically for different lengths of time, and which then were retrieved for various reasons other than failure of integration. This study's aim was to describe the bone–implant interface of such retrieved osseointegrated craniofacial implants by microradiography.

MATERIALS AND METHODS

The implants were removed from the bone with a thin surrounding bone collar with the aid of a trephine or round bur under conditions of adequate cooling with saline. At the time of removal, the implants were placed in 4% paraformaldehyde at 4°C until histological processing. The specimens were then dehydrated in an ascending series of alcohol rinses.

After dehydration, the specimens were embedded in methyl methacrylate and sectioned along their longitudinal axes with a diamond saw. Three sections were obtained from each implant. Microradiograms of each section were prepared according to the guidelines of Hallén and Röckert (10). The entire length of the threads of each implant was measured using a grid attached to a light microscope. The length of bone in contact with the thread was measured, and the bone metal contact (BMC) area was calculated in per cent for each section. Measurements from three sections of each implant were then pooled.

The significance of the differences recorded was assessed using Student's t-test on a Statworks computer program.

RESULTS

Altogether, 18 implants were retrieved from 10 patients between 1989 and 1997. All implants analysed were threaded fixtures of the Brånemark type, 3.75

mm in diameter (Nobel Biocare, Göteburg, Sweden). An overview of patients, gender, age, region of implantation, type of rehabilitation, reason for removal of implant, osseointegration time and number of implants included in the study is presented in Table I. The reasons for retrieval were unexplained pain ($n = 4$), inability to cope with the implants ($n = 2$), fracture of the central screw ($n = 2$), skin penetration problems ($n = 1$) and trauma ($n = 1$). The study group comprised six males and four females with a mean age of 53.4 years (range: 9–81 years). All implants were clinically stable at the time of removal, and mean osseointegration time was 2.95 years (range: 1–5 years). Six implants were removed from the temporal bone, seven from the maxilla and five from frontal bone.

In Fig. 1a, a threpined implant with surrounding bone collar is shown at the beginning of the preparation procedure. Representative microradiograms are shown in Fig. 1b, c. The implant attachment is a lamellar type of bone, which is in close contact with the implants over five threads. In the bone, vascular channels are present in the implant–bone contact area as well as in the bone at a distance from the implant. Haversian systems are visible, as are individual osteocyte lacunae. Bone turnover seems to be low, as there are only few resorption areas present.

Number of threads available for measurement varied from one implant to another, but ranged from 3–5 threads. BMC area ranged from 27–83.3% in the whole material. For the different regions, BMC in temporal bone implants ranged from 64.6–83.3%, in maxillary implants from 57.3–77%, and in frontal bone implants, non-irradiated and irradiated, from 44–46.6% and 27–35.6%, respectively. Comparing the different anatomical regions, BMC was similar in the temporal bone and maxilla ($p = 0.115$, t-test), whereas frontal bone implants had less BMC ($p = 0.002$, t-test) and irradiated frontal bone implants showed the least BMC ($p = 0.0001$, t-test). As for implants inserted into the frontal bone, irradiated regions showed less BMC than non-irradiated regions ($p = 0.024$, t-test).

Correlating BMC to age, the highest BMC values were recorded in the age group 41–60 years ($p = 0.003–0.009$, t-test), whereas there were no statistically significant differences between the 9-year-old patient and the oldest patient in the study. As for the relationship between BMC and osseointegration time, it was found that BMC increased over 2–5 years of osseointegration in the temporal bone ($p = 0.0001$, t-test). In the maxilla, BMC increased during the first 2 years of osseointegration ($p = 0.05$, t-test), and further follow-up until 4 years revealed no further increase in BMC. In the frontal bone, there were too few implants to allow for a similar comparison.

DISCUSSION

Histological studies of retrieved intra-oral implants in man have been published for different implant systems (11–14). Histological evaluation mainly revealed close contact between the implant and bone. In another paper presenting data of removal torques for craniofacial implants placed in the mastoid region, histological analysis of a 4-mm-long flange fixture was also presented. This analysis 4 months after installation verified a direct bone-to-implant contact in the temporal bone (15). In the only available report on extraoral craniofacial implants retrieved from humans allowing a quantitative analysis (9), a mean BMC of approximately 70% was found for all implants. In the present study, the mean BMC for all areas was 66.4%; if the implants inserted in irradiated bone are included, the mean BMC was 60.5%. These

Table I. *Patient data*

Patient	Gender	Age (years)	Region	Indication	Reason for removal	OI time (years)	n
1	Male	45	Temp	BAE	Fistula	5	1
2	Male	9	Temp	BAHA	Trauma	2	1
3	Male	59	Max	BAE	Pain	2	4
4	Male	68	Max	BAE	Fracture of s-screw	4	1
5	Female	51	Max	BAE	Pain	1	2
6	Female	46	Front	BAE	Pain	1.5	2
7	Female	72	Front	BAE	Pain	2	3
8	Male	56	Temp	BAHA	Not follow directions	5	1
9	Female	47	Temp	BAHA	Fracture of c-screw	5	1
10	Male	81	Temp	BAE	Not follow directions	2	2
	Mean	53.4			Mean	2.95	
	Range	9–81			Range	1–5	

Temp = temporal bone, Max = maxilla, Front = frontal bone, BAE = bone-anchored episthesis (prosthesis), BAHA = bone-anchored hearing aid, OI time = osseointegration time.

(a)

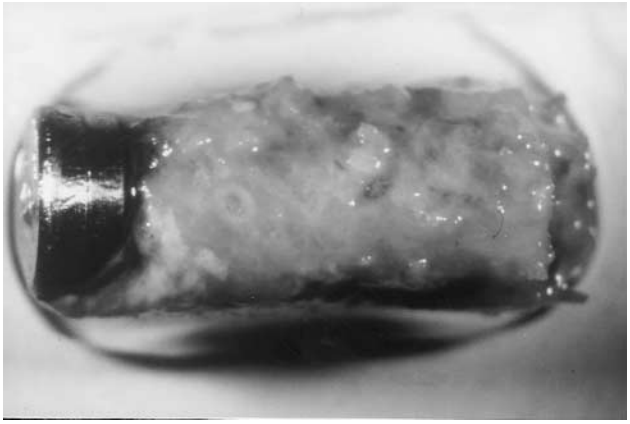
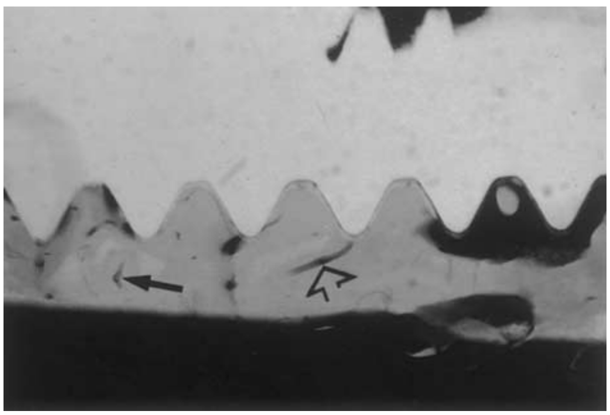
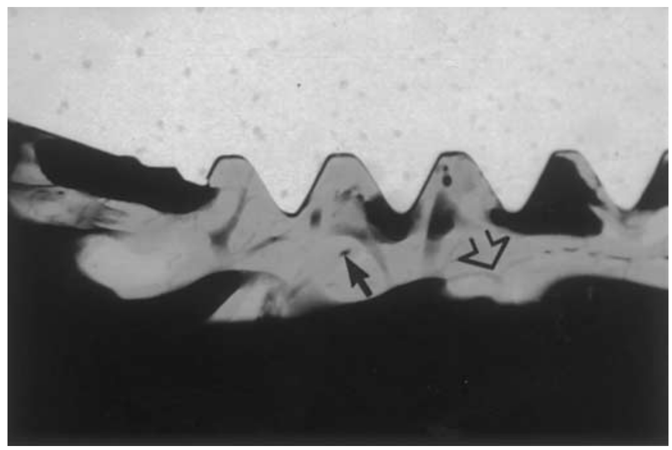


Fig. 1. (*a*) Implant removed from patient no. 5 due to pain. A border of bone surrounds the fixture. (*b*, *c*) Microradiogram from the same patient, two different sections. Lamellar type of bone is in close contact with the implant. Vascular channels (*arrows*) are visible, as are regular Haversian systems (*arrowhead*) (× 10).

(b)



(c)



figures are thus in accordance with the study of Bolind et al. (9). Reports of retrieved osseointegrated implants from the oral cavity show the mean BMC in the mandible to be approximately 80% and in the maxilla approximately 60% (16). It is believed that the higher proportion of bone contact of implants in mandibular bone reflects these bones' different morphology.

The mean loading time of the osseointegrated implants in this study was 3 years. It is known from experimental studies that screw-shaped titanium implants demonstrate increasing BMC with increased loading time (17). This phenomenon is also verified by microradiography, in that temporal bone implants showed an increased BMC over at least 5 years and maxillary implants showed an increased BMC over 2 years. Similar findings were reported in the study by Bolind et al. (9).

The possibility that the age of the patient might affect the outcome of osseointegration was considered. Though a limited number of implants could be analysed, there were indications that implants from the youngest and oldest patients might show lower BMC. On the other hand, implants from patients 1 and 10 had also been loaded for 2 years or less, a factor that could affect BMC. In our clinical files, there are no indications that the oldest patients should lose their implants more often. Younger patients have less bone volume at the time of implant surgery, but on the other hand, they show increased bone apposition with time (18). From clinical studies it seems that children can also be supplied with osseointegrated implants without notably higher failure rates. Thus, a reduced BMC does not necessarily mean that the implant will clinically fail with time.

Radiotherapy preceding implant surgery has, in numerous studies, been shown to cause higher implant failures (7, 19). The reason for this could be manifold, but increased bone resorption combined with reduced bone formation might be one important factor. Significantly decreased BMC in the present study seems to be in line with altered bone metabolism. It is possible that a BMC below 30% in a bone with predominant bone resorption could account for higher failure rates later on. Whether or not such a break point value exists needs to be proven, however.

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REFERENCES

1. Adell R, Lekholm U, Rockler B, Brånemark P-I. A 15-year study of osseointegrated implants in the treatment of the edentulous jaw. Int J Oral Surg 1981; 10: 387–416.
2. Tjellström A. Osseointegrated systems and their application in the head and neck. Adv Otolaryngol Head Neck Surg 1989; 3: 39–70.
3. Håkansson B, Carlsson P, Tjellström A. The bone-anchored hearing aid—Design, principles and audiometric results. Ear Nose Throat J 1994; 78: 670–5.
4. Tjellström A, Granström G, Bergström K. Osseointegrated implants for craniofacial prostheses. In: Weber RS, Miller MJ, Goepfert H, eds. Basal and squamous cell skin cancers of the head and neck. Baltimore/Philadelphia/London/Paris: Williams and Wilkins, 1996: 313–30.
5. Tjellström A, Granström G. Long-term follow-up with the bone anchored hearing aid. A review of the first 100 patients between 1977 and 1985. Ear Nose Throat J 1994; 73: 112–14.
6. Tjellström A, Granström G. One stage procedure to establish osseointegration. A zero to five years follow-up report. Am J Otolaryngol 1995; 109: 593–8.
7. Granström G, Bergström K, Tjellström A, Brånemark P-I. A detailed study of titanium fixture implants lost in irradiated tissues. Int J Oral Maxillofac Implants 1994; 9: 653–62.
8. Jacobsson M, Albrektsson T, Tjellström A. Tissue-integrated implants in children. Int J Ped Otorinolaryngol 1992; 24: 235–43.
9. Bolind P, Acton C, Albrektsson T, et al. Histologic evaluation of retrieved craniofacial implants. Otolaryngol Head Neck Surg (In press).
10. Hallén O, Röckert H. The preparation of plane parallel sections of desired thickness of mineralized tissues. Proceedings of the Second International Symposium on X-ray Microscopy and X-ray Microanalysis 1960: 169–72.
11. Albrektsson T, Eriksson AE, Friberg B, et al. Histologic investigation on 33 retrieved Nobelpharma implants. Clin Mat 1993; 12: 1–9.
12. Albrektsson T, Åstrand P, Becker W, et al. Histologic studies of failed dental implants. A retrieval analysis of four different oral implant designs. Clin Mat 1992; 10: 225–32.
13. Piattelli A, Scarano A, Piattelli M. Histologic observations on 230 retrieved dental implants. 8 years experience (1989–1996). J Periodontol 1998; 69: 178–84.
14. Albrektsson T, Brånemark P-I, Hansson H-A, Lindström J. Osseointegrated titanium implants. Requirement for ensuring a long-lasting direct bone-to-implant contact in man. Acta Orthop Scand 1981; 52: 155–70.
15. Tjellström A, Jacobsson M, Albrektsson T. Removal torque of osseointegrated craniofacial implants. A clinical study. Int J Oral Maxillofac Implants 1988; 3: 287–9.
16. Albrektsson T, Meredith N, Wennerberg A. Osseointegration of the craniofacial implant. In: Tolman D, Brånemark P-I, eds. Osseointegration in craniofacial reconstruction. Chicago/London/Berlin/Rio de Janeiro/Tokyon: Quintessence Publishing Co, 1998: 3–13.
17. Johansson C, Albrektsson T. Integration of screw implants in rabbit. A 1-year follow-up of removal of titanium implants. Int J Oral Maxillofac Implants 1987; 2: 69–75.
18. Granström G, Tjellström A. Guided tissue-generation in the temporal bone. Ann Otol Rhinol Laryngol 1999; 108: 349–54.
19. Granström G, Tjellström A, Brånemark P-I. Osseointegrated implants in irradiated bone. A case–control study using adjuvant hyperbaric oxygen therapy. J Oral Maxillofac Surg 1999; 57: 493–9.

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