Brånemark Implants and Osteoporosis: A Clinical Exploratory Study

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ABSTRACT

Background: Oral implant treatment on patients with poor jaw-bone texture has shown increased failure rates in series of studies.

Purpose: The purpose of the present study was to retrospectively follow patients with osteoporosis of the axial or appendicular skeleton, including the jaw bone, being subjected to oral implant treatment. The outcome of inserted implants, when using an adapted bone site preparation technique and extended healing periods, was evaluated.

Materials and Methods: Based on data obtained from preoperative radiographs, patient medical history, and resistance of the jaw bone perceived during drilling, 14 of 16 patients were referred to the Osteoporosis Laboratory, Sahlgren University Hospital, Göteborg, Sweden, for bone density measurements. Two patients already had an established diagnosis of osteoporosis. Fourteen jaws in 13 patients (11 females, 2 males; mean age: 68 yr) were subsequently subjected to oral implant treatment with a total of 70 implants (Brånemark System®) of various designs. The mean follow-up period was 3 years and 4 months (range: 6 mo–11 yr).

Results: Osteoporosis of either the spine, the hip, or both regions was diagnosed in 14 patients, and osteopenia was diagnosed in 2 patients. Two implants failed, and the overall implant survival rate at the end of the study period was 97.0% for maxillae and 97.3% for mandibles. The marginal bone resorption at the 1-year follow-up concurs with the outcome of other studies, irrespective of the preoperative bone texture present.

Conclusion: The outcome of the present study showed that implant placement in patients in whom the average bone density showed osteoporosis in both lumbar spine and hip as well as poor local bone texture may be successful over a period of many years.

KEY WORDS: bone quality, osseointegration, osteoporosis, titanium implants

Osteoporosis is characterized by a reduction in bone mass and is diagnosed on patients who sustain low-trauma fractures. In the report by Melton and colleagues,[1] it was estimated that at least 90% of all hip and spine fractures among elderly white women should be attributed to osteoporosis. It was also stated that, regardless of fracture type, attribution probabilities were less for men than for women and generally less for nonwhites than whites. Many studies in vivo have shown the usefulness of bone mineral density (BMD) measurements for predicting risk of future fracture, although a substantial overlap in BMD between fracture and nonfracture populations has been reported.[2–4] The most widely used technique of measuring BMD of the spine, the hip, and the whole body has been dual photon absorptiometry (DXA).[5]

von Wowern and colleagues reported a significant correlation between the bone mineral content (BMC) of forearms and lumbar spine but failed to show a corresponding relation between these regions and the mandible.[6] In a more recent study by Klemetti and coworkers,[7] it was found that the mandibular cortical BMD clearly correlated with that of the lumbar spine

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and femoral neck, whereas the mandibular trabecular BMD did not. According to von Wowern and Stoltze,[8] both the buccal and lingual mandibular cortices showed increasing porosity with age, albeit contradictory results have been reported with regard to the relation between the inferior cortical shape and width versus patient age and state of osteoporosis.[7,9–13] Thus, the diagnosis of osteoporosis of the hip and spine does not necessarily imply osteoporosis of the jaw.

Encouraging results of oral implant treatment on patients with established osteoporosis previously have been reported.[14–16] In a study by Becker and colleagues,[17] it was concluded that osteoporosis of the peripheral skeleton (radius or ulna), as measured with DXA, was not afflicted with an increased oral implant failure rate. Instead, the local bone quality, classified during implant placement, was the best predictor for implant risk.

The goal of the present investigation was to retrospectively study the outcome of oral implant treatment on patients with an established diagnosis of severe osteoporosis of the axial and appendicular skeleton as well as of the jaws.

MATERIALS AND METHODS

The present study comprised 16 patients, who were referred to the Brånemark Clinic, Dental Health Care, Göteborg, Sweden, for oral implant treatment. The patients were examined following a standardized protocol including clinical and radiographic assessments.[18–20] Based on the information obtained from the preoperative radiographic examination (panoramic, lateral, and where appropriate, tomographic radiographs), using the bone quality classification (scores 1–4) proposed by Lekholm and Zarb,[18] the medical history (skeletal fractures, reduced height and weight, medication, heavy smoking), as well as the bone resistance perceived during drilling, the patients were referred for further investigations at the Osteoporosis Laboratory, Sahlgren University Hospital, Göteborg, Sweden. Bone mineral density measurements were executed of the lumbar spine and the hip. The patients were also investigated using laboratory tests to exclude any form of secondary osteoporosis. Osteoporosis was defined according to World Health Organization (WHO) criteria.[21] A bone density below a 2.5 standard deviation (SD) of the mean peak bone mass for young women in the lumbar spine and hip was defined as osteoporosis, and a bone mass between −1 and −2.5 SD was defined as osteopenia. All but two patients, the latter with multiple low-trauma fractures, were presented with the diagnosis of general osteoporosis owing to the referrals from the oral surgeon to the Osteoporosis Laboratory. Three patients refrained from implant treatment for various reasons after being thoroughly investigated.

Fourteen jaws in 11 female and 2 male patients (mean age: 68 yr; range: 55–79 yr) were treated with oral implants, representing six edentulous maxillae and five completely and three partially edentulous mandibles. The surgical procedure was, in general, performed as a two-stage technique,[22] although in one edentulous mandible, implants and abutments were placed at one occasion for immediate loading.[23] In one maxilla, chin-bone block grafts were used prior to implant placement,[24] and in one posterior mandible, a nerve transposition in connection with implant placement was executed.[25] Owing to the brittle bone character of the latter patient, only one implant could be inserted in the posterior mandible.

Seventy implants (Brånemark System, Nobel Biocare AB, Göteborg, Sweden) of various designs (standard and self-tapping) and diameters (3–5 mm) were used (Table 1). Implants were inserted using an adapted bone site preparation technique.[26] Thus, implants of diameter 3.0 mm (custom made) and 3.3 mm were placed in bone sites prepared to a final diameter of 2.0 to 2.3 mm, implants of diameter 3.75 mm were placed in sites of diameter 2.70 to 2.85 mm, and implants of diameters 4 mm and 5 mm were inserted in sites of diameter 3.0 mm. Furthermore, the mean healing periods were extended to 8.5 months and 4.5 months in maxillae and mandibles, respectively.[26] Ten to 14 days following the abutment operation, the prosthetic procedure was commenced, and implant-supported fixed constructions were manufactured either in gold alloy or in titanium.[27,28]

Intraoral radiographs were obtained at abutment operation, at bridge insertion, and at the 1-year check-up. Furthermore, when longer follow-up periods were at hand, radiographic examinations were carried out after 5 and 10 years of function, respectively. For each implant, the postoperative radiographs were evaluated regarding the marginal bone height and its change over time, and the bone–fixture interface zone was evaluated with regard to changes indicating loss of integration. Registrations of the marginal bone level at the mesial and distal surfaces, calculated as a mean value per implant, at abut-

ment operation and at the 1-year check-up, were performed to the closest 0.1 mm by one observer, using a seven times magnifying lens. The marginal bone loss was determined during the first year of function.

The mean follow-up period of loaded implants and prosthetic constructions was 3 years and 4 months (range: 6 mo–11 yr). Three patients were lost to follow-up (deceased), after 11 months, 2 years and 3 months, and 11 years of function, respectively.

RESULTS

The distribution of jaw-bone quality scores, according to the index described by Lekholm and Zarb,[18] revealed an overall majority of quality 4 sites (Figure 1). With regard to patient 13, the bone texture of the maxilla was perceived as quality 4 during the grafting procedure, whereas at implant placement 6 months later, the bone was classified as quality 3. Two additional sites (patient 8) were of quality 3. In all, 62 of 70 sites were judged as quality 4.

With regard to the BMD measurements, 14 patients fulfilled the WHO criteria of osteoporosis and 2 patients met the criteria of osteopenia of either the lumbar spine, the hip, or both regions (Table 2). The average t-score value was in lumbar spine –2.74 SD and in total hip –2.52 SD. When compared to an age-matched control, the corresponding z-values were –0.78 and –0.76 in lumbar spine and total hip, respectively. Medical treatment was initiated where appropriate, using calcium, vitamins A and D, bisphosphonates, estrogen, and selective estrogen receptor modulator (SERM).

Two implants were lost during the study period, both at second-stage surgery, revealing an overall implant survival rate of 97.1%. The corresponding figures for maxillae and mandibles were 97.0% and 97.3%, respectively. The patient (7) subjected to a nerve transposition procedure of the left mandible presented with a jaw fracture at abutment operation, which was probably caused by a minor trauma during the healing period. The fracture was asymptomatic, and the patient was unaware of this consequence, although the fracture line coincided with the bone–implant interface and the implant was found mobile. The patient received two implants 6 months later to support a fixed partial denture. The second lost implant was a 3.0-mm diameter fixture placed in the premolar region of an edentulous maxilla (patient 10). A fixed construction supported by five implants was manufactured with the subsequent reinsertion of an additional implant 6 months later. Thus, all treated patients were equipped with fixed implant-supported constructions.

Measurements of the radiographic marginal bone levels at abutment connection and at the 1-year follow-up revealed a mean bone loss (with SD) of 0.6 mm (± 0.6 mm) during the first year of function. A frequency distribution of marginal bone level change by fixtures is shown in Figure 2. One patient was withdrawn (deceased) before the 1-year check-up and two additional patients only attained 6 months of follow-up at the end of the study period. No radiographic signs of

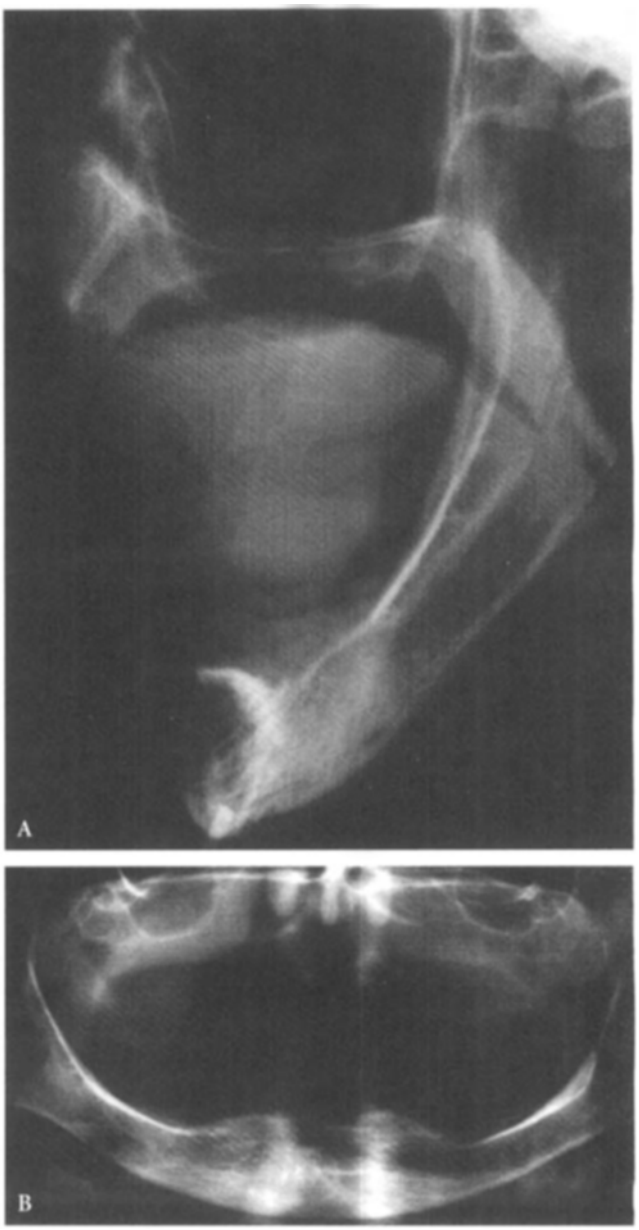

Figure 1. Radiographic views of maxilla and mandible revealing bone quality 4, according to the proposed classification by Lekholm and Zarb.[18]

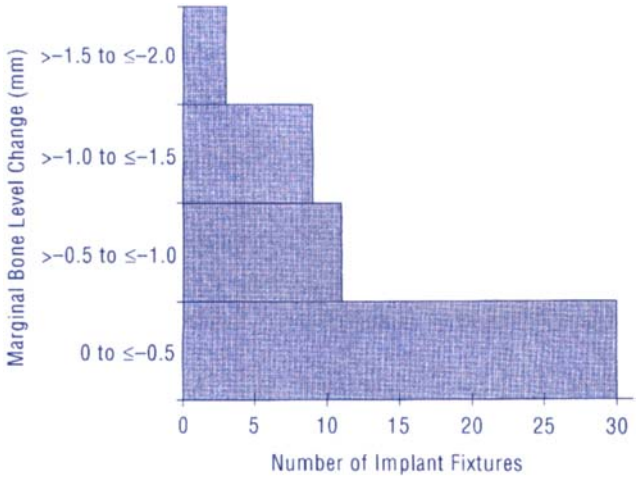

Figure 2. Frequency distribution of marginal bone level change (mm) by fixtures during the time interval between abutment connection and 1-year follow-up.

loss of integration were noted. For those patients followed for more than 1 year, only small changes of the marginal bone level were noted over time.

DISCUSSION

The successful outcome of the present study (97.1%), using oral implants in patients with general osteoporosis, concurs with some oral implant reports of quality 4 bone[29–32] and exceeds by far the ones reported for poor bone texture by others.[33–35] The current concept of using an adapted bone site preparation technique to obtain the best primary implant stability possible and extended healing periods to obtain the best secondary implant stability possible may, to a certain extent, explain the favorable outcome.[26] Histomorphometry and removal torque

TABLE 1. *Distribution of Implants with Regard to Length,* Diameter, and Design*

Patient Number	Jaw Type	Region					
		R3	R2	R1	L1	L2	L3
1	Total maxilla	13 mm Standard	10 mm Standard	10 mm Standard	10 mm Standard	10 mm Standard	
1	Total mandible	15 mm MkII	15 mm MkII	15 mm MkII	15 mm Standard	15 mm Standard	15 mm Standard
2	Total mandible	18 mm MkII	18 mm MkII	18 mm MkII	18 mm MkII	15 mm MkII	
3	Total mandible	10 mm MkII	13 mm MkII	13 mm MkII	13 mm MkII	10 mm MkII	
4	Total maxilla	15/4 mm Standard	15 mm MkII	15 mm MkII	15 mm MkII	15 mm MkII	18/4 mm Standard
5	Total mandible	13 mm MkII	11.5 mm MkII	13 mm MkII	11.5 mm MkII	10 mm MkII	
6	Total maxilla	MkII	10 mm MkII	13 mm MkII	13 mm MkII	13 mm	
7	Partial mandible				10/5 mm† Standard		
8	Parial mandible	Standard	8.5/5 mm MkII	18 mm MkII	18 mm Standard	8.5 mm	
9	Total maxilla	10.4 mm Standard	10 mm Standard	18 mm Standard	18 mm Standard	10/4 mm Standard	10/5 Standard
10	Total maxilla	10 mm Standard	15/3 mm	10 mm Standard	10 mm Standard	15/3.3 mm	15/3 mm†
11	Total mandible	Standard	10/5 mm Standard	10/5 mm Standard	10 mm Standard	10/5 mm Standard	10/5 mm
12	Total maxilla	15/4 mm Standard	15 mm Standard	13 mm Standard	13 mm Standard	13 mm Standard	15/4 mm Standard
13	Total maxilla	10/4 mm Standard	11.5 mm Standard	8.5 mm Standard	7 mm Standard	10 mm Standard	10/4 mm Standard

*Other than 3.75 mm; †failed implant.
R = right implant; L = left implant; 3, 2, 1 = third, second, first posterior position. MkII = Mark II self-tapping implant.

TABLE 2. Distribution of Osteoporosis and Osteopenia, as Measured with Dual Photon Absorptiometry*

Patient Number	Lumbar Spine (SD)	Hip Bone (SD)
1	> 2.5	> 2.5
2	> 2.5	> 2.5
3	> 2.5	> 2.5
4	> 2.5	> 2.5
5	> 2.5	> 2.5
6	> 2.5	2.3
7	> 2.5	0.6
8	2.3	> 2.5
9	1.5	1.5
10	2.2	> 2.5
11	> 2.5	> 2.5
12	> 2.5	> 2.5
13	2.2	Normal
14	2.0	> 2.5
15	2.3	> 2.5
16	> 2.5	> 2.5

*Definitions according to WHO criteria: osteoporosis: > 2.5 standard deviations (SD) below the mean peak bone mass for young women; osteopenia: > 1.0 and < 2.5 SD.

measurement studies on rabbits have shown a time-dependent increase in implant stability,[36–38] and the cause for this may be the increased bone-to-metal contact seen over time. In the study by Mori and co-workers,[39] osteoporosis-like conditions were created in rabbit bone, and implants that were placed in test and control animals exhibited similar successful results. However, the establishment of bone-to-metal contacts in test animals, similar to the ones in controls, required 50% longer healing periods. With regard to clinical studies, Friberg and co-workers showed that implant stability in bone of low density,[40] as measured with resonance frequency,[41] was seen to "catch up" over time with the stability obtained in bone of medium and high densities.

Of the 16 patients investigated at the Osteoporosis Laboratory, 13 were subjected to implant treatment. The reason to include the three untreated patients was to emphasize the role of the dental clinician in diagnosing general osteoporosis. The information obtained from available radiographs, patient medical history, and the hand-felt perception of bone resistance during drilling should be used to guide the clinician in determing whether further investigation (DXA) of the skeleton is required. Early diagnosis of osteoporosis and proper medication (calcium, A and D vitamins, bisphosphonates, estrogen, SERM) may prevent future skeletal fractures.[42–45] With regard to bisphosphonates, such drugs have been found to reduce the number and activity of osteoclasts and to increase the BMD of the lumbar spine, femur neck, and the total body as well as to markedly reduce the risks for new vertebral and hip fractures.[46,47]

In patient 13, the bone quality was perceived differently during the grafting procedure compared to the situation at implant placement 6 months later. One cause for this change in density may have been the influence of the denser mandibular bone graft at implant insertion. According to Lundgren and colleagues,[48] however, dense grafted particulated mandibular bone assumed bone volume fractions similar to those of the recipient maxillae 6 to 12 months postoperatively. Thus, a more conceivable cause may have been the initiated regeneration process as a result of the mechanical intervention during the grafting procedure.[49] With regard to the two patients with failed implants, similar improved bone densities were noted at reinsertion of implants (i.e., after a 6-month healing period).

The concept of direct loading, as performed in patient 11, has shown predictable and encouraging results.[23,50–52] However, the experience of executing this procedure in quality 4 bone is limited, and the main reason for applying the technique in this patient was that she had extensive oral and general health problems. The outcome after 2 years has remained successful.

The mean value of the marginal bone resorption (0.6 mm) seen after 1 year of function is in accordance with other studies, irrespective of the preoperative bone quality present.[22,53–55]

CONCLUSION

The outcome of the present study clearly showed that implant placement in patients with general osteoporosis and with poor local bone textures may be successful over a period of many years. By adapting the preparation technique to achieve the best primary implant stability possible and by extending the healing period to achieve the best secondary stability possible, implants were found to behave similarly to those placed in denser bone textures.

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