Iliac Crest Autogenous Bone Graft versus Alloplastic Graft and Guided Bone Regeneration in the Reconstruction of Atrophic Maxillae: A 5-Year Retrospective Study on Cost-Effectiveness and Clinical Outcome

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ABSTRACT

Background: Reconstruction of the atrophic maxillae with autogenous bone graft and jawbone-anchored bridges is a well-proven technique. However, the morbidity associated with the concept should not be neglected. Furthermore, the costs for such treatment, including general anesthesia and hospital stay, are significant. Little data are found in the literature with regard to a cost-benefit approach to various treatment alternates.

Purpose: The aim of this retrospective study was to compare from a health-economical and clinical perspective the reconstruction of the atrophic maxillae prior to oral implant treatment either with autogenous bone grafts harvested from the iliac crest or the use of demineralized freeze-dried bone (DFDB) in combination with a thermoplastic carrier (Regeneration Technologies Inc., Alachua, FL, USA) and guided bone regeneration (GBR).

Materials and Methods: A total of 26 patients (13 + 13) were selected and matched with regard to indication, sex, and age. The study was performed 5 years after the completion of the treatment. Implant survival, morbidity, and complications were analyzed. Furthermore, a detailed analysis of the total cost for the respective treatment modality was performed, including material, costs for staff, sick leave, etc.

Results: The study revealed no statistical difference with regard to implant survival for the respective groups. The average total cost, per patient, for the DFDB group was 22.5% of the total cost for a patient treated with autogenous bone grafting procedures.

Conclusions: The study concluded that reconstruction of atrophic maxillae with a bone substitute material (DFDB) in combination with GBR can be performed with an equal treatment outcome and with less resources and a significant reduced cost in selected cases compared with autogenous bone grafts from the iliac crest.

KEY WORDS: autogenous bone graft, biomaterials, bone augmentation, cost-effectiveness, dental implants, DFDB, GBR, iliac crest, membrane

INTRODUCTION

Rehabilitation of edentulous patients demonstrating an atrophic maxillae[1,2] with a combination of a bone graft procedure and a jawbone-anchored fixed prosthesis is a well-proven treatment modality in dentistry.[3–5]

Autogenous bone has been considered the gold standard for grafting procedures because of its osteogenic and osteoinductive capability. The choice of donor site is often based on the amount of bone needed for reconstruction. In the case of totally edentulous maxillae needing reconstruction, extraoral bone grafts usually

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harvested from the iliac crest (IC) have been the primary source.[6–11]

These procedures are related to a varying degree of morbidity and discomfort for the patients postoperatively.[12–14] Furthermore, this method is quite resource demanding and requires general anesthesia and, very often, 1 day to 4 days of hospital stay following surgery. The admission period is usually followed by a period of sick leave and rehabilitation because of the morbidity of the treatment.[15] Hence, there is a great interest and focus in the development of alternate techniques in order to reduce the discomfort for the patient as well as reduce the operating time, morbidity, hospitalization time and, consequently, a reduction of the total cost for the treatment. The rapid development and use of various bone substitute materials have opened up new possibilities in the treatment of the atrophic maxillae with acceptable success rates.[16–23] These concepts offer several advantages. The surgery can be performed in local anesthesia in an outpatient setting in most cases. The need for a second surgical site can also be avoided.

Furthermore, we believe that the cost-effectiveness of different reconstruction techniques in relation to treatment success is poorly analyzed in the literature, with the exception of the prosthetic outcome of implant treatment.[24,25] Hence, the aim of the present retrospective study was to compare two different approaches for reconstruction of the atrophic maxillae both with regard to clinical outcome and cost-effectiveness.

MATERIALS AND METHODS

Grafting Procedures and Implant Treatment

A total of 26 patients were retrospectively included in the study. The patients were treated at the Department of Oral and Maxillofacial Surgery, NÄL Medical Centre Hospital, Trollhättan, Sweden. They were originally referred for implant treatment in the upper jaw and required bone reconstruction prior to implant placement. The inclusion criterion in the present follow-up study was 5 years of clinical function of the implant restoration following reconstruction. The first group of patients ($n = 13$, mean age 53 years, range 26–80, 6/7 male/female ratio) was reconstructed by means of an autogenous bone graft harvested from the IC. The second group ($n = 13$, mean age 64 years, range 38–84, 5/8 male/female ratio) comprised of patients treated with demineralized freeze-dried bone (DFDB) in combination with a thermoplastic carrier (Regeneration Technologies Inc., Alachua, FL, USA) and guided bone regeneration (GBR). The two groups were matched with regard to age, sex, and the number of implants placed in the maxilla.

The surgical protocol for patients receiving bone grafts from the IC is well described in the literature.[11] In brief, the maxilla was augmented under general anesthesia by the placement of buccally positioned monocortical IC bone grafts. The grafts were harvested from the medial surface of the anterior ilium. The bone blocks were trimmed and positioned at the buccal surface of the maxilla. Finally, they were secured in place by means of transosseous miniscrews. The patients received antibiotics (V-Penicillin, 2 g twice daily for 10 days). Postsurgical instructions included a soft diet for 2 weeks and appropriate oral hygiene that included twice-daily rinsing with 0.1% chlorhexidine mouthwash. Patients were not allowed to wear their denture for 2 weeks postoperatively. A total of 6 months of healing were allowed prior to fixture installation.

Implant placement was performed under local anesthesia according to standard protocol (Brånemark System®, Nobel Biocare AB, Gothenburg, Sweden). The implants were allowed to heal for 4 months, followed by a subsequent abutment connection.

The second group (DFDB + GBR) was treated with local anesthesia Xylocaine–Adrenalin (1:80,000, AstraZeneca, Södertälje, Sweden). Following a crestal incision extending to the molar region, a buccal and palatal mucoperiosteal flap was raised, exposing the atrophic maxillae. The buccal bone surface was cleansed of remaining soft tissue by curettage. Buccal miniscrews were applied, and multiple perforations of the buccal bone plate were carried out by means of a small round bur. DFDB (1–2 cc) in a thermoplastic carrier (Regeneration Technologies Inc.) was then applied buccally and contoured into the desired shape. Finally, the graft material was covered with resorbable barrier membranes (BioGide, Geistlich AG, Wolhusen, Switzerland). Periosteal-releasing incisions were carried out in order to obtain a tension-free closure over the graft material. The flap was re-adapted and sutured with horizontal mattress and interrupted nonresorbable sutures (4-0 GORE-TEX®, W.L. Gore & Associates Inc., Flagstaff, AZ, USA). Healing was allowed for 6 months prior to fixture installation. This followed the same protocol as described for the (IC) group. Implant survival was

TABLE 1 Implant Survival (5 Years Follow-Up) for the IC and DFDB Groups

Implant Survival	Mean	SD	Minimum	Maximum	*p* Value
IC	96.1	13.9	50	100	.55 (n.s.)
DFDB	98.7	4.7	83	100	

Student's *t*-test.
DFDB = demineralized freeze-dried bone; IC = iliac crest graft; n.s. = not significant.

assessed at the time of the abutment connection and 5 years following the completion of treatment according to the success criteria proposed by Albrektsson and colleagues.[26]

Cost-Effectiveness Analysis

The total cost for the procedures in the respective groups (IC) and (DFDB) were assessed (the costs were presented as SEK. 1 SEK = 0.09 EUR, January 2009). By the use of a designated database for surgical planning at the hospital, the exact operating time could be calculated. The system also gave information regarding number of staff involved in the respective procedures, including the anesthesia team. By help from the administrative/financial office at the hospital, an average overhead cost per hour for the respective staff category was estimated. The same procedure was utilized for the use of additional materials per operation. The costs for dental implants and associated products were not included in the analysis (for details see Table 2).

Statistical Analysis

Student's *t*-test was used for comparison of treatment costs and implant survival rate. The levels of significance were set at $p < .05$.

RESULTS

Clinical Outcome

The mean implant survival rate in the (IC) group after 5 years was 96.1% (range 50.0–100.0, SD 13.8). In the (DFDB) group, the survival rate was 98.7% (range 83.0–100.0, SD 4.7). There was no statistically significant difference ($p < .55$) between the respective groups (Table 1).

Cost-Effectiveness Analysis

In general, statistically significant reductions ($p < .0001$) in costs were found both for materials and staff separately in all comparisons between the DFDB and the IC groups. The overall total costs for treatment in the DFDB group were 22.4% of the average cost for the corresponding treatment in the IC group. (Table 2).

DISCUSSION

The reconstruction of the atrophic edentulous maxilla with an autogenous bone graft and endosteal implants is today a well-established treatment with good prognosis.[10] Furthermore, this treatment modality generates a significant improvement on the patient's quality of

TABLE 2 Health-Economic Analysis for the Respective Treatment Modality

	Mean	SD	Minimum	Maximum	*p* Value
IC staff costs	3,905	11,546	2,372	6,680	<.0001
DFDB staff costs	889	2,314	594	1,561	
Overhead costs IC	24,486	9,204	13,840	48,440	<.0001
Overhead costs DFDB	5,778	2,013	2,863	8,855	
Total cost IC	28,393	9,427	16,897	51,825	<.0001
Total cost DFDB	6,379	1,909	3,457	9,779	

Student's *t*-test.
Costs estimated in SEK.
DFDB = demineralized freeze-dried bone + guided bone regeneration; IC = iliac crest graft.

life.[12,13,27] There are mainly three different techniques described in the literature for bone reconstruction: onlay, sinus inlay, and interpositional grafting. In most situations, a relatively large quantity of bone is required. Hence, the IC is the most commonly used donor site with regard to quantity and safety of the harvest procedure.[11] In the present study, patients receiving buccal onlay grafts (IC group) were selected for comparison. Consequently, all patients participating in the present study demonstrated a similar type of atrophy of the maxilla with adequate height but insufficient width of the crest. Sjöström and colleagues reported in a literature survey an implant survival rate for bone grafting from the IC ranging from 79% up to 90%, with the latter utilizing a two-stage technique.[10] Recently, an impressive 11- to 16-year long-term follow-up by Nyström and colleagues[28] revealed an 85% implant survival and a 100% bridge survival utilizing IC graft in combination with a LeFort I osteotomy. The slightly lower success rate is probably explained by a more advanced atrophy of the cases selected for a combination treatment with osteotomy and bone graft procedure as compared with our material. In another publication by the same authors (Nyström and colleagues[29]) using an onlay technique similar to our material, the implant survival rate was 90% after a mean follow-up period of 11 years. The slight difference in success rate as compared with the present study could be explained by a slow progressive bone resorption over time. This has been proposed by Nyström and colleagues.[28,29]

In the present study the mean implant survival rate for the IC group (buccal onlay) was 96.1% after 5 years in clinical function. The DFDB + GBR augmented group demonstrated an implant survival rate of 98.7% after the same time frame of clinical function. Both these results correspond very well with previous results in the literature. In our opinion, bone augmentation using a combination of DFDB and GBR offers an alternate to more advanced bone grafting procedures, especially in atrophic maxillae where a buccal augmentation is required. It is clear that this is a patient group that is more or less considered oral invalids, and a significant improvement in quality of life definitely can be achieved by means of this rehabilitation regardless of procedure chosen.[29] The reconstruction in a patient with an atrophic edentulous maxilla with bone and endosteal implants is an extensive treatment. However, limited data are found regarding the total costs for the society with regard to hospitalization, surgical time, staff needed, sick leave, etc. In the present study, an attempt was made to objectively compare the total costs for the respective treatment regime (IC vs DFDB groups). The differences between the two groups were highly significant ($p < .0001$). A total evaluation demonstrated that the DFDB group basically, in all parameters measured, was treated to a cost that was approximately 23% of the costs generated in the IC group. This should also be put into the context that both groups demonstrated a similar implant survival rate (96.1% and 98.7%, respectively).

Traditionally, grafting procedures utilizing an autogenous bone have been considered the gold standard of augmentation. From a biological point of view, this, in some aspects, holds true. The drawbacks have been a somewhat unpredictable bone resorption over time.[7] Recent findings have demonstrated that when GBR (barrier membranes) procedures are performed in conjunction with the use of bone substitute materials, only limited resorption can be seen.[20–22] In the present study, equal or survival rates were noted ($p < .55$) for implants placed in the DFDB group. A strict and identical patient selection with regard to shape and anatomy of the edentulous maxilla was difficult to perform.

The respective groups were matched with regard to age, sex, and number of implants placed. Although the present study demonstrated favorable results for the DFDB group, it is our opinion that all patients with a similar situation as described in the present study cannot be treated with DFDB + GBR technique exclusively. However, a more strict selection for patients subjected to iliac bone grafting could thus be recommended. Because of the significant reduction in costs and also in morbidity for the society and the patients, the use of GBR procedure in conjunction with DFDB can be recommended.

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