The aim of this study was to evaluate the morbidity after anterior iliac crest bone harvesting by comparison of 2 approaches: medial and intracortical.

Patients and Methods: Between April 2006 and February 2010, 73 consecutive subjects underwent anterior iliac crest bone harvesting. The sample was divided in 2 groups: 37 subjects treated with the medial approach and 36 with the intracortical approach. Patients were monitored during their hospital stay, considering the postoperative complications, the analgesic requirements, resumption of the ambulation, and length of stay. Postoperative controls were performed at 7, 14, and 30 days 6 and 12 months after surgery. A questionnaire on patient's satisfaction and complaints was released.

Results: The 2 approaches resulted in significant statistical differences in 3 areas: the average time of operation, recovery of gait capabilities, and duration of the postsurgical pain were lower when intracortical approach was used.

Discussion and Conclusion: The low postsurgical morbidity can be related to the minimal muscular detachment, and the risk of fracture is reduced. Bone wax is not necessary for the hemostasis. We consider intracortical approach to be ideal in the case of selected transversal maxillary atrophies.

Key Words: Bone substitute, morbidity, preprosthetic surgery, maxillary atrophy, bone graft, iliac crest

(J Craniofac Surg 2013;24: 369–372)

Intracortical Versus Anteromedial Approach for Iliac Crest Bone Harvesting in Preprosthetic Surgery: A Randomized Prospective Clinical Trial

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Purpose: The aim of this study was to prospectively compare the anterior-medial approach with the anterior-intracortical approach in a uniform group of patients with the same type of atrophy and the same amount of bone harvested, considering the postoperative morbidity. The ideal technique should ensure a good amount of bone, giving the patient the lowest postoperative morbidity. This is why minimally invasive techniques have been described involving the use of trephine.1–3 These techniques, however, provide only cancellous bone and do not allow the harvesting of a corticocancellous bone block. The anteromedial-monocortical approach is the most preferred by the most of the authors4 because it allows to obtain a volume of bone similar to the volume obtained with the bicortical approach but associated with a lower postoperative morbidity. The aim of this study was to prospectively compare the anterior-medial approach with the anterior-intracortical approach in a uniform group of patients with the same type of atrophy and the same amount of bone harvested, considering the postoperative morbidity and acceptability of these procedures by patients.

MATERIALS AND METHODS

All patients affected by maxillary atrophy who came to our observation between April 2006 and February 2010 were included in our study. The following were the inclusion criteria:

1. Transverse maxillary atrophy with linear length between 3 and 8 cm;
2. Absence of musculoskeletal diseases;
3. No preoperative pain in the sacroiliac region;
4. No preoperative hypoesthesia in the innervation area of the lateral femoral cutaneous and subcostal nerve; and
5. Absence of pathologic alterations of the oral mucosa.

Exclusion criteria were as follows:

1. Patients with cleft lip and palate;
2. Patients younger than 18 years;
3. Patients treated with antidepressant drugs;
4. Previous surgical procedures of the iliac region;
The questionnaire was released (see Fig. 1). The affected areas with a cotton swab keeping the patient’s eyes closed. Tactile sensitivity was tested by touching the patient’s skin in the regions of innervation of subcostal and lateral femoral cutaneous nerve. During the checks, the following parameters were evaluated: the size of the scar, any abdominal hernias, and lack of sensitivity in contour ridge defects, instability of the sacroiliac joint, appearance of the ambulation, and length of stay. Postoperative controls were performed at 7, 14, and 30 days 6 and 12 months after surgery. Patients were monitored during their hospital stay, considering the postoperative complications, the analgesic requirements, resumption of the ambulation, and length of stay. Postoperative controls were performed at 7, 14, and 30 days 6 and 12 months after surgery. Throughout the checks, the following parameters were evaluated: the contour ridge defects, instability of the sacroiliac joint, appearance and size of the scar, any abdominal hernias, and lack of sensitivity in the regions of innervation of subcostal and lateral femoral cutaneous nerve. Tactile sensitivity was tested by touching the patient’s skin in the affected areas with a cotton swab keeping the patient’s eyes closed. The questionnaire was released (see Fig. 1).

Surgical Technique, Anterior-Intracortical Approach

After the preparation of the surgical field of the designated iliac crest, the hand is used to displace the skin medially, placing the incision lateral to the iliac crest. The incision is made through the displaced skin directly over the crest, the limits of the incision not extending to within 2 cm of the anterior superior iliac spine and the tubercle posteriorly. Then, an incision is performed down through the subcutaneous fat with a low-power electric scalpel to the insertion of the oblique fascia on the crest. It was then possible to continue the dissection using a scissor to avoid damage to the muscle until the insertion of the oblique external muscle on the superior margin of the iliac crest. The periosteum incision was performed along the aponeurosis of the external oblique muscle and the aponeurosis of the gluteal muscle.

The external oblique abdominal and iliac muscles were reflected in a subperiosteal plane. The superior margin of the iliac crest was then exposed without reflections and detachments both medially and laterally. A corticocancellous block of bone was outlined using an oscillating bone saw from the inner table of the crest, keeping the limits of the bone graft 2 mm far from the lateral and the medial margin of the crest. With curved manual scalpels, it was then possible to remove the corticocancellous bone graft, and additional cancellous bone can be harvested using a curette. Bone grafts are successively stored in saline solution. Hemostasis is performed through the use of a resorbable hemostatic sponge inserted and compressed in between the 2 cortices. This allows to avoid using bone wax. Closure was performed following the layers, making sure to connect the 2 aponeuroses (oblique external muscle and the medial gluteal muscle). No drainage was used. The skin is finally sutured using a 4.0 nylon vertical mattress. A light pressure dressing was applied for 24 hours to prevent seroma formation (Fig. 2, intracortical).

Surgical Technique, Anterior-Monocortical Medial Approach

Surgical time of the incision and of the fascial detachment are the same in the intracortical approach. Once arrived to the subperiosteal plane, the lateral portion of the gluteal muscles must not be detached. The detachment is performed medially, elevating the iliac muscle by subperiosteal way until approximately 4 to 5 cm in depth. Iliac muscles are retracted medially using orthopedics retractors. The superior and medial graft areas are delimited with an oscillant bone saw, whereas the inferior margin of the graft is delimited with a curved scalpel. It was then possible to outline a corticocancellous bone block that can be mobilized using meniscus scalpels. Sharp bony edges were smoothed with bone files, and after meticulous hemostasis, with the use of bone wax, closure was performed. If the hemostasis is correctly performed, drainage is not used. A compressive medication was applied for 2 to 3 days.

Statistical Analysis

Mean with 95% confidence interval (CI) and SD were used to report the normally distributed quantitative variables, and median with interquartile range (IQR), maximum and minimum values, were used to report the nonparametric variables. Saphiro-Wilk test and normality plots were used to assess the normality of the distribution of the values. According to our observation, some variables show values coming from a distribution not normal and to avoid assumptions about their distribution, we preferred to use the nonparametric tests available in the software used.

FIGURE 1. Questionnaire.

<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question 1: How long did you experience pain at the hip donor site?</td>
<td></td>
</tr>
<tr>
<td>1. Had no pain</td>
<td></td>
</tr>
<tr>
<td>For ___ days (please sign number of days)</td>
<td></td>
</tr>
<tr>
<td>Question 2: On the following scale from 1 to 100 put a sign which indicates the worst pain that you experienced at the bone graft site</td>
<td></td>
</tr>
<tr>
<td>0 (one - 100 worst imaginable)</td>
<td></td>
</tr>
<tr>
<td>Question 3: Did you have any problem walking after surgery due to your bone graft? For how long (pain and use of crutches)?</td>
<td></td>
</tr>
<tr>
<td>For ___ days (please indicate the number of days)</td>
<td></td>
</tr>
<tr>
<td>Question 4: Was there any numbness in the hip or leg from the side where the bone graft was harvested?</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Question 5: How satisfied are you with the scar at the hip donor site?</td>
<td></td>
</tr>
<tr>
<td>0 (not satisfied, 100 very satisfied)</td>
<td></td>
</tr>
<tr>
<td>Question 6: Considering the experience would you be willing to have bone graft harvested from your hip if you needed further reconstructive surgery?</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Question 7: Would you recommend this surgery to friends and colleagues?</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>
from a normally distributed population, whereas some others do not. Therefore, we used Student t test for parametric analysis and Mann-Whitney U test or Pearson $\chi^2$ test for analysis of nonparametric data and analysis of the 0 to 100 visual analogue scales.

The analysis was performed using SPSS software version 12.0 for Windows (SPSS Inc., Chicago, IL). Statistical significance was set at $P = 0.05$.

RESULTS

The sample was represented by 73 subjects: 37 in group A and 36 in group B. Fifteen subjects from group A (40.5%) were males and 22 (59.5%) were females, whereas 16 subjects (44.4%) from group A were males and 20 (55.6%) were females ($P = 0.736$). The mean age was 49.3 years, and mean BMI was 23.26 kg/m$^2$. The mean (SD) age in group A was 51.3 (9.4) years (95% CI, 48.16–54.44), whereas the mean (SD) age in group B was 47.2 (10.3) years (95% CI, 43.8–50.7; $P = 0.084$). The mean (SD) BMI was 23.4 (2.8) kg/m$^2$ in group A (95% CI, 22.5–24.3) and 23.1 (2.5) kg/m$^2$ in group B (95% CI, 22.3–24.0; $P = 0.633$).

None of the patients enrolled in this study had preoperative disorders or instability of the sacroiliac joint.

Median amount of bone harvested was 12 cm$^3$ in group A (IQR: 3; minimum, 9, and maximum, 15) and 12 cm$^3$ in group B (IQR: 3; minimum, 9, and maximum, 15; $P = 0.398$). Median surface of onlay graft was 5 cm$^2$ in group A (IQR: 1; minimum, 3, and maximum, 8) and 5 cm$^2$ in group B (IQR: 1; minimum, 3, and maximum, 8; $P = 0.874$). Median blood loss was 40 mL in group A (IQR: 18; minimum, 20, and maximum, 60) and 35 mL in group B (IQR: 14; minimum, 20, and maximum, 60; $P = 0.316$). Median surgical time was 27 minutes in group A (IQR: 16; minimum, 21, and maximum, 37) and 25 in group B (IQR: 4; minimum, 18, and maximum, 32; $P < 0.001$; see Fig. 3).

All scars were well established except 2 scars in group A (1 hypertrophic scar and 1 stretched scar) and 1 scar in group B (1 stretched scar). No patients had postoperative numbness, except 2 patients in group A (1 having side-subcostal numbness and 1 having femorocutaneous numbness) and 1 patient in group B (having side-subcostal numbness). None of the patients had articulation instability after the surgical intervention. All patients stated that they would undergo the surgical operation again and would recommend it to relatives and friends, except for 2 patients from group A (2.7% of the whole sample, 5.4% of group A). The mean (SD) number of days with pain after bone harvesting was 10.3 (6.0) days (95% CI, 8.3–12.3) in group A and 5.8 (2.7) days (95% CI, 4.9–6.7) in group B ($P < 0.001$). The mean number of days with problematic ambulation was 14.6 (3.2) days (95% CI, 13.5–15.6) in group A and 6.3 (2.5) days (95% CI, 5.4–7.1) in group B ($P < 0.001$). The median value for pain after a week from the intervention was 40 (IQR: 20; minimum, 20, and maximum, 70) on a scale from 0 to 100 according to patients from group A and 30 (IQR: 10; minimum, 20, and maximum, 50) according to patients from group B ($P = 0.055$). The median value for scar satisfaction after 1 month was 80 (IQR: 10; minimum, 20, and maximum, 100) on a scale from 0 to 100 according to patients from group A and 90 (IQR: 20; minimum, 70, and maximum, 100) according to patients from group B ($P = 0.041$). The median value of scar extension was 5 cm (IQR: 3; minimum, 4, and maximum, 7) in group A and 5 (IQR: 1; minimum, 3, and maximum, 6) in group B ($P = 0.043$; Figs. 4 and 5).

DISCUSSION

The ideal material for the purpose of preprosthetic reconstructions should be osteogenic, osteoconductive, osteoinductive, and biocompatible. The only material that comprehend all these features is the autogenous bone.

Among the extraoral donor sites, the iliac crest is the one preferred by most of the authors because it guarantees an easy surgical access and a large amount of bone that can be harvested. Two are the approaches to the iliac crest: anterior and posterior. Many authors underline the fact that the high quantity of corticocancellous bone that can be harvested and the lower risk of the postoperative morbidity (intended as both pain and difficulties in ambulation) are the advantages of the posterior approach. The major disadvantage, instead, is the fact that the patient needs to be turned around during the surgery impeding a double-equipped teamwork, therefore making the procedure longer. On the other hand, the anterior approach is more easily accessible, making it possible for the surgeon to intervene on both the receiving site and the donor simultaneously, hence reducing the operational time. According to current scientific literature, the prolonged pain during the postsurgical period and the limited gait capabilities are the disadvantages associated with the anterior approach. Nevertheless, it has been reported by Zijderveld et al. that 3 of 146 patients under observation presented fracture of the anterior iliac spine. The anterior approach can be divided into 4 different types, medial monocortical, lateral monocortical, bicortical, and intracortical. The lateral monocortical and the bicortical types are the ones that result in a higher postsurgical morbidity because they include the detachment of the gluteal muscles, which play a very significant role in the ambulation of the patient. Differently, the anteromedial monocortical approach is usually associated with a much faster recovery of the gait capabilities and a shorter duration of the postsurgical pain because it engages in the detachment of the iliac muscle alone and reports a recovery of the gait activities within 2 weeks (mean, 10.4 days) in most.

FIGURE 3. Surgical time (in minutes) boxplot. Group A versus group B. Median surgical time in group A: 27 minutes (IQR: 16; minimum, 21, and maximum, 37). Median surgical time in group B: 25 (IQR: 4; minimum, 18, and maximum, 32). Mann-Whitney U test, $P < 0.001$.

FIGURE 4. Problematic ambulation after surgery (in days) boxplot. Group A versus group B. The median (SD) number of days with problematic ambulation was 14.6 (3.2) days (95% CI, 13.5–15.6) in group A and 6.3 (2.5) days (95% CI, 5.4–7.1) in group B ($P < 0.001$).
of the patients (89%). \(^{11}\) The results we obtained in group A, using the anteromedial cortical approach, are in perfect conjunction with the current scientific reports.

To reduce the postsurgical morbidity, several minimally invasive techniques, mainly consisting in the use of trephine, have been used. \(^{7,9}\) Nevertheless, failure to obtain corticocancellous bone blocks and the limited quantity of bone that can be harvested reserve these techniques to special cases only.

Freilich and Sándor\(^9\) in 2006 described the intracortical approach as an ambulatory procedure in cases of small maxillary atrophy limited to alveolar segments of just 1 or 2 teeth. Mirovsky and Neuwirth\(^{11}\) in 2000 named this technique intracortical, despite that the objective of the harvest in their study was mainly the cancellous bone. In addition, they reported a failed decrease of the postsurgical pain when using this type of approach as opposed to the external monocortical technique.

We report that the intracortical approach is to be associated with a lower postsurgical morbidity than the anteromedial monocortical one. In addition, the mean quantity of bone that can be harvested was 12 cm\(^3\) with an average bone graft surface of 5 cm\(^2\). This allowed us to transversally reconstruct the maxillary segments up to 8 cm of linear length. Those patients who were in need of major reconstructions had been already excluded from the case study beforehand because the intracortical approach could not have sufficed in their case.

The low postsurgical morbidity can probably be related to the minimal muscular detachment necessary. \(^{14}\) In addition, by leaving both the medial cortical and lateral cortical intact, the risk of fracture is reduced.

We compared patients from group A and group B, who have been treated respectively with anteromedial and intracortical approach and were uniformed in age, BMI, and quantity of harvested bone. The results showed significant statistical differences in the mean time of operation, the recovery of gait capabilities, and the duration of the postsurgical pain. Although we have not reached a statistical significance, the intensity of pain in a week from the harvesting was inferior in group B, with only 2 patients claiming that they would choose not to go through the process again given that they were from group A.

Another advantage of the intracortical approach is the opportunity to obtain hemostasis simply through the use of a resorbable hemostatic sponge inserted and compressed in between the 2 corticals. This allowed us to avoid using bone wax, which, in the study of Verborgt et al, had to have been removed for having caused, after 19 years, a retroperitoneal granuloma.\(^{17}\)

**CONCLUSIONS**

The comparison of the median monocortical approach on the iliac crest to the intracortical approach resulted in significant statistical differences in 3 areas: the average time of operation, recovery of gait capabilities, and duration of the postsurgical pain. In addition to these data, the advantages that avoiding the use of bone wax offers and the lower risk of fractures bring us to consider the intracortical approach to be ideal in the case of selected transversal maxillary atrophies.

**REFERENCES**