Complications of Minimally Invasive Tibial Bone Harvesting: Risk Factors and Treatment

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Purpose: The aim of this retrospective study was to analyze complications, risk factors, and corresponding treatment regarding the medial approach to harvesting tibial bone. Materials and Methods: Consecutive cases at Yokohama City University Hospital were analyzed for complications of tibial particulated bone and marrow harvesting with the medial approach. The condition of bone marrow, duration of harvesting, and complications were evaluated. The complication rate and correlations between bone marrow conditions and duration of bone harvesting were assessed. The corresponding treatments for the complication were also observed. Results: Thirty cases of tibial particulated bone and marrow harvesting for alveolar ridge or sinus floor augmentation before implant therapy from 2005 to 2014 were analyzed. Twenty-one patients had healthy bone marrow, whereas nine patients had fatty bone marrow. The duration of operation in patients who had both spontaneous pain and gait disturbance was approximately 56 minutes, which was significantly longer than that (approximately 40 minutes) in patients who had only gait disturbance (P < .05). A strong correlation between fatty bone marrow condition and bone harvesting time was seen. The correlation between bone marrow condition and bone harvesting time for fatty marrow was stronger than that for healthy marrow with a trend to significant difference (P = .082). The minor and major complication rate was 96.7% and 6.6%, respectively. Two patients showed postoperative infection on the tibial harvesting site. One of them, who had fatty bone marrow, showed methicillin-resistant Staphylococcus aureus–caused osteomyelitis of the tibia, which needed to be debrided and reconstructed with vancomycin-containing bone cement. Conclusion: A duration of less than 40 minutes for harvesting time may decrease the risk of minor complications. Bone marrow condition influenced tibial bone harvesting duration, which may result in increasing the risk of complications. Regarding major complications, it was considered that wound protection was more important even if the marrow condition was healthy. Int J Oral Maxillofac Implants 2019;34:987–991. doi: 10.11607/jomi.7201

Keywords: bone augmentation, cancellous bone and marrow, complication, morbidity, tibial bone harvesting

Reconstruction of the alveolar bone has become a common procedure to place dental implants in anatomically compromised sites. Various techniques such as the use of short implants and application of bone substitutes have been developed to avoid invasive bone harvesting. Tibia bone is used for such bone augmentation treatment in the oral and maxillofacial area. Compared with iliac bone harvesting, tibial harvesting has some advantages such as short exposure time, less morbidity, and early mobility, whereas the amount of bone is limited.1,2 The classical approach to the tibia has been a lateral approach.3–5 However, the less-invasive medial approach with short incisions has been reported for tibia harvesting.1,6,7 The medial approach is closer and safer for reaching the bone, and the procedure is unnecessary to detach the superior portion of the anterior tibialis muscle.8 Although the same amounts of bone could be harvested from the medial compared with the lateral approach,8 the cortical bone to access the medullary cavity is thick in the medial approach. Hence, the defect area of

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cortical bone seems to be much larger for the medial approach compared with the lateral approach. The size of the cortical bone window of the tibia influences bone strain, which may affect bone healing and any complications in either the medial or lateral approach. According to a review of complications after tibial harvesting in more than 20 reports and 1,000 patients, the occurrence of major complications such as infection, fracture, and prolonged gait disturbance was 5.5%. Moreover, of 12 reports that described more than 29 patients each, only 1 described the absence of any major complications.

The aim of this study was to describe complications and risk factors associated with tibial bone harvesting by the medial approach.

**MATERIALS AND METHODS**

**Study Design**

This retrospective study analyzed complications and related factors of tibial particulated cancellous bone and marrow harvesting for alveolar bone augmentation. This study was approved by the ethics committee of Yokohama City University Hospital (B091112001). Inclusion criteria were patients ≥ 20 years of age who underwent tibial bone harvesting with the medial approach at Yokohama City University Hospital. Informed consent was obtained from all patients after sufficient explanation of the study protocol. Patients' sex and age, harvesting procedure, condition of bone marrow, and complications related to the tibia were analyzed.

**Tibial Harvesting**

The tibial bone harvesting technique was based on the procedure reported by Hernández-Alfaro et al. A 10-mm horizontal line was made following the skin incision line, 2 cm under and 2 cm medial to the anterior tibial tuberosity (Fig 1a). Following exposure of the periosteum, a 15-mm horizontal line was made on the periosteum in order to expose the bone surface. Cortical bone with a thickness of approximately 5 mm was removed with an 8-mm manual trephine drill. Cancellous bone marrow was then harvested from the proximal portion of the tibia using a bone curette. The harvested cancellous bone marrow was placed into a disposable syringe and strongly compressed to measure its amount (Fig 1b). The harvesting time from the placement of the skin incision to the completion of suturing after harvesting of the required amount as per the simulation was calculated. After the required amount was harvested, both the periosteum and skin were sutured (Fig 1c). The harvested bone was milled to make particulated bone and marrow and used for augmentation. After confirmation of hemostasis with hemostatic agents and compression, the wound was dressed with a pressure dressing, which consisted of gauze and an elastic stocking, to maintain continuous compression until the following day when the pressure dressing was removed. Intravenous antibiotics (Cefazolin 1 g) were administered 30 minutes before surgery, and continued every 12 hours until the next morning postoperatively. Patients were hospitalized. Oral antibiotics (cefcapene pivoxil 100 mg), which were initiated after completion of the intravenous antibiotic course, were administered every 8 hours for a week. The bone marrow condition of each patient was evaluated. The cancellous bone marrow was assessed as being healthy or fatty. Harvested marrow was filled in a 5-mL plastic syringe, and the weight was measured. Then, the marrow was compressed until the liquid component was completely pushed out from the syringe, and the volume of remaining marrow was measured. Calculating the ratio of volume to weight, the value < 0.5 was considered as “fatty marrow.” Postoperatively, the appearance of spontaneous pain, gait disturbance, or infection was monitored. Spontaneous pain persisting less than 1 week or gait disturbance persisting less than 2 weeks was considered to be a minor complication. Infection was considered to be a major complication.

**Statistical Analyses**

Correlations between bone marrow conditions and duration of bone harvesting were assessed with Pearson correlation coefficient with StatFlex (Artech). The value of the correlation coefficient was converted to z value using Fisher’s z transformation table and statistically compared. Also, the relation between minor complications and duration was analyzed with the Student t test. Differences were considered significant when P values were <.05.
RESULTS

Tibial Harvesting
This study comprised 13 male and 17 female patients who underwent tibia bone harvesting for sinus floor or alveolar ridge augmentation from 2005 until 2014. The mean patient age was 53 years (range: 33 to 80 years). The mean amount of harvested bone was 3.6 mL, and the mean duration of harvesting time was 50 minutes. Regarding bone marrow condition, 21 patients had healthy marrow and 9 patients had fatty marrow. The amount of bone and the duration of the operation according to the bone marrow condition are summarized in Table 1. The mean amount of harvested bone and mean duration of harvesting time in healthy bone marrow patients were 3.9 mL and 46.4 ± 15.8 minutes, respectively. The mean amount of harvested bone and mean duration of harvesting time in fatty bone marrow patients were 3.2 mL and 52.3 minutes, respectively. The correlation between the harvested bone amount and the harvesting time was weak in patients with healthy marrow, whereas a strong correlation was seen in patients with fatty marrow (Fig 2a). The difference of the correlation coefficient between healthy and fatty marrow was trending to statistical significance (Fig 2b).

Complications
Major (infection) and minor (spontaneous pain < 1 week and/or gait disturbance < 2 weeks) complications are summarized in Table 2. Twenty-nine patients showed gait disturbance. Of these, 13 patients showed spontaneous pain simultaneously. The duration of harvesting time in patients who showed both gait disturbance and spontaneous pain was significantly longer than that in patients who showed only gait disturbance (Table 3). The harvesting time of patients who had no

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Summary of Bone Marrow Condition, Age, Sex, Harvesting Amount, and Harvesting Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marrow</td>
<td>Age (y)</td>
</tr>
<tr>
<td>Healthy</td>
<td>53 (range: 33–73)</td>
</tr>
<tr>
<td>Fatty</td>
<td>57 (range: 37–80)</td>
</tr>
</tbody>
</table>

Fig 2  Correlation between duration of operation time and amount of harvested bone. (a) Correlations of all procedures. Red points indicate patients who have both spontaneous pain and gait disturbance, while blue points indicate patients who have only gait disturbance. (b) Correlations in healthy marrow (black) and fatty marrow (red). The correlations between operation time and harvesting amount in fatty marrow were strong. The correlations of healthy and fatty marrow had a marginally significant difference.

Table 2  Summary of Minor and Major Complications and Rate (%)

<table>
<thead>
<tr>
<th>Complications</th>
<th>No.</th>
<th>Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minor (multiple per patient)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spontaneous pain ( &lt; 1 wk)</td>
<td>13</td>
<td>43.3</td>
</tr>
<tr>
<td>Gait disturbance ( &lt; 2 wk)</td>
<td>29</td>
<td>96.7</td>
</tr>
<tr>
<td>Major (single)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infection</td>
<td>2</td>
<td>6.6</td>
</tr>
<tr>
<td>Oral antibiotics and observation</td>
<td>1</td>
<td>3.3</td>
</tr>
<tr>
<td>IV antibiotics and debridement</td>
<td>1</td>
<td>3.3</td>
</tr>
</tbody>
</table>

Table 3  Summary of Minor Complications and Duration of Operation

<table>
<thead>
<tr>
<th>Complications</th>
<th>No.</th>
<th>Duration of operation (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spontaneous pain and gait disturbance</td>
<td>13</td>
<td>56.2 ± 16.2*</td>
</tr>
<tr>
<td>Only gait disturbance</td>
<td>16</td>
<td>39.5 ± 13.5</td>
</tr>
</tbody>
</table>

*P < .05.
complications was 15 minutes. Among the 30 bone harvesting times, wound infection as a major complication occurred two times. Therefore, the major complication rate was 6.6% (2/30 times). The wound infection in a patient who had healthy marrow appeared a week after surgery and was treated conservatively under the consultation of an orthopedic doctor. After 2 weeks of antibiotic therapy using oral clarithromycin (400 mg/day), the wound became clear. The spontaneous pain that occurred while walking disappeared in a month, while the contact pain disappeared in 2 months. The other patient with wound infection needed surgical treatment of an infectious tibia. The marrow condition of the patient was fatty. The tibia and the skin surrounding the tibia caused necrosis with pus discharging. Methicillin-resistant \textit{Staphylococcus aureus} was detected from the wound. Under consultation of an orthopedic doctor, the patient needed to undergo debridement of the necrotic tibia and surrounding skin. The bone defect was filled with vancomycin containing hydroxyapatite block, and the skin defect was reconstructed with local rotation skin flap. Intravenous antibiotic therapy using vancomycin was performed for 2 weeks. The patient had to be forced to stay in the hospital for a month to rehabilitate to walk. After hospitalization, the patient needed to use a stick to walk for 3 years, but currently, the patient has recovered and is able to walk without any devices. Among the remaining 30 patients, gait disturbances were mild and disappeared within a couple of weeks. In terms of minor complications, a bloody spot on the leg appeared in 15 patients and spontaneous pain that disappeared within a week appeared in 13 patients. The minor and major complications are summarized in Table 2.

**DISCUSSION**

This retrospective study described bone marrow condition influencing the duration of tibial bone harvesting time. The correlation between harvested bone amount and bone harvesting time from fatty bone marrow was significantly stronger than that from healthy marrow. Tibial bone harvesting is widely used as a less-invasive technique for harvesting cancellous bone and marrow. In the present study, the mean harvested amount was 3.6 mL and the mean harvesting time was 50 minutes; these values were smaller and longer, respectively, than those reported in previous studies of proximal tibial harvesting.\(^1,6,11,12\) Approximately one-third of patients had fatty bone marrow in the present study, resulting in longer harvesting times compared with previous studies. In the present study, the harvested bone was measured in a highly compressed condition. Marchena \textit{et al}\(^15\) reported that the volume of harvested bone changed by compressing it to almost half. Because the loose fatty marrow was more compressible than the dense healthy marrow, the harvested amount in the present study was reasonable. The prevalence of major complications was comparatively higher than previous reports.\(^1,3,4,6,11,12\) Three patients showed severe gait disturbance that lasted more than 3 weeks because of postoperative pain and infection. In particular, in two patients with infection, one patient played a sport that caused wound dehiscence only 4 days after bone harvesting, and the other patient did work that required loading the tibia only 3 days after bone harvesting. Moreover, methicillin-resistant \textit{Staphylococcus aureus} was detected from the wound. The patient had many hospital stays because of other diseases, indicating that the patient had a relatively higher risk of methicillin-resistant \textit{Staphylococcus aureus} infection compared with other patients. Therefore, methicillin-resistant \textit{Staphylococcus aureus}–caused osteomyelitis of the tibia occurred. Tibial bone necrosis is a considerably severe complication that would require amputation of the tibia. However, in that case, hydroxyapatite-based bone cement, in which antibiotics could be filled, were fortunately effective to prevent amputation.

These complications may have been prevented by restricting mobility. With regard to restricting mobility, some reports have advocated immediate weight bearing,\(^4,7,11\) while others have suggested limitations on weight bearing.\(^5,12,13\) There is no clear opinion with regard to the prevention of major complications after tibial harvesting. Because one complication observed in this study could have been prevented by restricting mobility, a certain level of restriction on mobility should be imposed after tibial harvesting. Excessive loading on the harvest site can cause a fracture, but not in wound dehiscence, bleeding, or infection. A bone-breaking loading test after tibial harvesting from cadavers showed that bone removal from the proximal tibia resulted in a significant decrease in the axial load capacity, independent of patient sex and age; this finding suggested that partial loading of up to half an individual’s body weight was favorable during the first postoperative week.\(^14\) Thor \textit{et al}\(^15\) reported that bone strength was considerably decreased by a rectangular bone defect. According to a review of complications after tibial harvesting in more than 20 reports and 1,000 patients,\(^10\) the occurrence of major complications such as infection, fracture, and prolonged gait disturbance was 5.5%. Moreover, of 12 reports that described more than 30 patients each, only 1 described the absence of any major complications.\(^10\)

The present study described bone marrow condition influencing bone harvesting duration, which would cause severe major complications. Treatment of bone harvesting according to the patient’s condition
should be planned to minimize morbidity, and correspon-
ding treatment for complications should be sup-
posed to prevent unrecoverable complications.

CONCLUSIONS

Durations of more than 40 minutes to harvest tibia
bone may increase risk of minor complications; bone
marrow condition influenced tibial harvesting dura-
tion. However, it was considered that wound protec-
tion after surgery was more important even if the
marrow condition was healthy. Then, attention should
be paid to resistant strain for patients who have had
many hospitalizations.

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