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ORIGINAL ARTICLE

# Iliac crest towards alveolar processes or mandibular inferior margin in mandibular reconstruction with a vascularized iliac bone flap: which is better?

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## Abstract

**Objective** The study aims to compare differences among iliac bone flaps with different iliac crest orientations for the repair of mandibular defects with an aim to analyze their advantages, disadvantages, and effects.

**Material and methods** Clinical data and computed tomography scans of all patients who underwent iliac bone flap repair of the mandible in Peking University School and Hospital of Stomatology from January 2016 to April 2021 were collected. Patients were divided into the iliac crest towards alveolar process (Group A) and the iliac crest towards mandibular inferior margin (Group B). Software was used to measure corresponding indicators. The results obtained for the groups were statistically analyzed.

**Results** The study included 78 patients (25 and 53 in groups A and B, respectively). The symmetry of the LC-type defect was better in group A ($p < 0.05$). The all-bone width of the alveolar process side in group A was greater than 6 mm; in 15 cases of group B, the width was less than 6 mm ($p < 0.05$). The intermaxillary distance of two sites were higher in group B ($p < 0.05$). The bone cortical thickness was significantly thicker in group A ($p < 0.05$).

**Conclusion** One year after the mandibular body defect was reconstructed with a vascularized iliac bone flap, the iliac crest towards alveolar process group showed better bone symmetry, width, intermaxillary distance, and cortical thickness to meet the planting requirements.

**Clinical relevance** The use of an iliac crest towards alveolar process may be a better approach for mandible reconstruction.

**Keywords** Iliac bone flap · Iliac crest · Mandibular defect · Mandibular reconstruction · Intermaxillary distance · Cortical bone

## Introduction

Mandibular defects lead to a series of problems such as local oral dysfunction and facial deformity. Therefore, the reconstruction and restoration of the shape and function of the mandible are particularly important [1]. With the development of microvascular surgery technology, the success rate of vascularized bone transplantation has increased to 95–98% [2–4]. Hence, this method has become the first choice for defect repair [5]. Since Taylor et al. [6] first proposed the reconstruction of the mandible with an iliac bone flap in 1989, the approach has been widely used in clinical settings because of its advantages of affording a sufficient bone height and a natural curved edge [7].

Dental implants play an important role in the functional reconstruction of the mandible, and whether the transplanted bone meets the basic conditions of implantation is the basis of functional reconstruction. The iliac crest is one of the most ideal implants for alveolar reconstruction because it provides a sufficient bone height and width for implantation and has a thick cortical layer [8]. The shape of the iliac crest is so similar to the inferior margin of the mandible that the iliac crest is often oriented toward the inferior margin of the mandible to restore the shape of the lower edge of the

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mandible [9]. It is debatable whether the iliac crest should orient the alveolar process or the inferior margin of the mandible when a vascularized iliac flap is used to reconstruct mandibular defects. Hence, this study was aimed at comparing the characteristics of different iliac crest orientations after mandibular reconstruction.

## Materials and methods

### Subject selection

Patients who underwent vascularized iliac bone flap transfer at the Department of Oral and Maxillofacial Surgery, Peking University School of Stomatology, Beijing, China, from January 2016 to April 2020 were retrospectively evaluated. The inclusion criteria were as follows: the presence of a defect involving the chin and body of the mandible, no involvement of the mandibular angle and condyle, and presence of at least a 1.5-cm-wide bone reserved at the posterior edge of the ascending branch. Maxillofacial spiral CT was performed 1 year after the surgery. The exclusion criteria were as follows: (1) patients who underwent radiotherapy and chemotherapy before and after the operation; (2) patients younger than 18 years of age; (3) patients with bone metabolism-related diseases; (4) patients with a failed iliac flap operation. The patients were divided into two groups according to iliac crest orientations: iliac crest oriented to the alveolar process (group A) and iliac crest oriented to the mandibular inferior margin (group B) (Fig. 1). Patients' postoperative pathological results, HCL classification [10], and number of donor segments were recorded.

### Data acquisition and processing

Spiral CT of the maxillofacial region was performed at the Radiology Department by using a CT scanner (Optima CT520 Pro, voltage: 120 kV, slice thickness: 1.25 mm). The patients were in the supine position with the head in the center of the headrest, keeping the orbital plane perpendicular to the ground. They were instructed to occlude the posterior teeth during the scan. CT data for 1 year after surgery was exported to the ".DICOM" (Digital Imaging and Communications in Medicine) format and then was imported into Proplan CMF 3.0 (materialized, Leuven, Belgium) and Simplant (DENTSPY Implants, Hasselt, Belgium) to generate a 3D model of the skull.

### Measurement method

The symmetry of the mandible was evaluated by referring to the method proposed by Thiesen et al. [11]. In Proplan CMF, the Frankfort plane was adjusted as a horizontal reference. The midsagittal plane was defined by a vertical plane that passed through the anterior nasal spine and skull base points. It divided the mandible into healthy and affected sides. Regarding space coordinate, straight lines parallel to the X-axis through the lower edge point of the mental foramen, the mandibular angle point (Go point), and the outermost point of the condyle (LC point) of the healthy side were drawn, and the intersections of those lines and the lateral surface of the mandible were marked. As shown in Fig. 2, the distance from each intersection to the midsagittal plane was measured to calculate the asymmetry rate $Q$ [12] for each pair of intersections (Fig. 2):$Q = \frac{G-k}{G} \times 100\%$, $G$ and $K$ each represented the vertical distance from the outermost

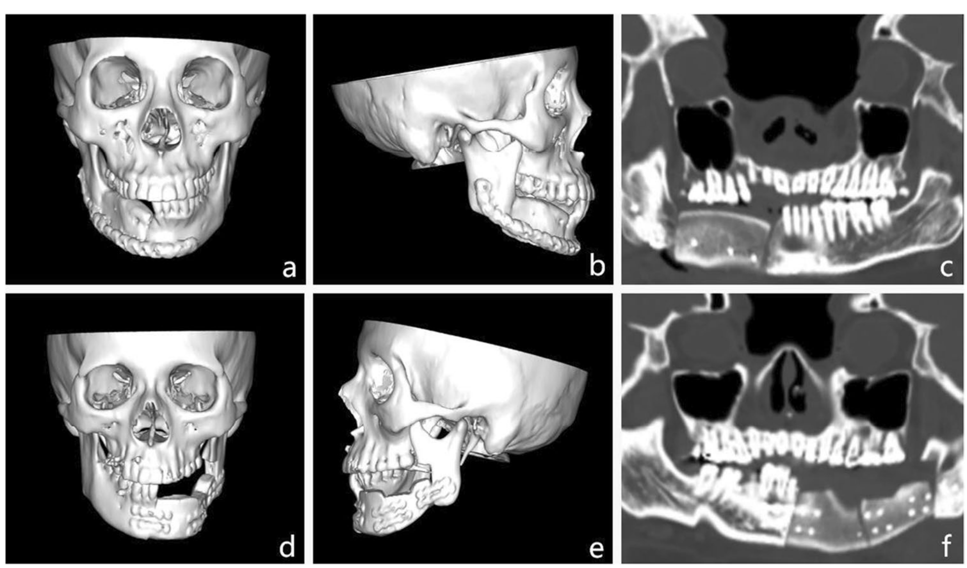


**Fig. 1** According to the orientation of iliac crest, they were divided into groups. **a**, **b**, **c** The figure in the first row shows Group A, which the iliac crest towards alveolar process; **d**, **e**, **f** the second row shows Group B, which iliac crest towards mandibular inferior margin

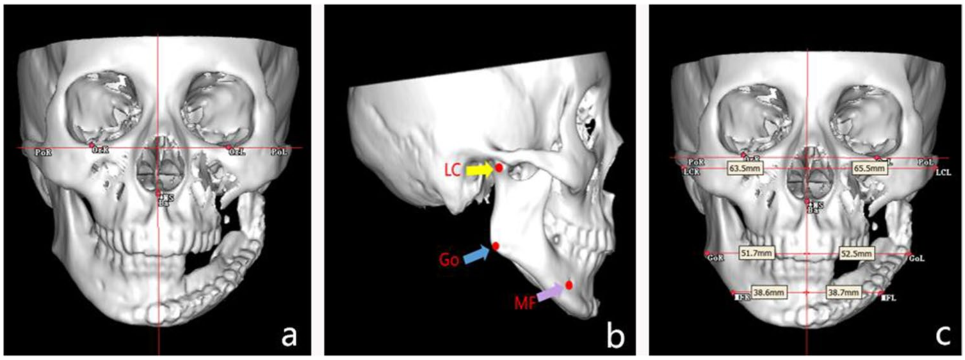


**Fig. 2** Measurement of symmetry. **a** Establishment of a coordinate system with the Frankfort horizonal plane and the midsagittal plane; **b** selection of the outermost point of the condyle (LC point), the mandibular angle point (Go point), and the lower edge point of mental foramen (MF point) of the healthy side and marking them with yellow, blue, and purple; **c** recording the distances through which these three points paralleled the *X*-axis from each intersectional point to the midsagittal plane

intersection of the left or right sides to the median sagittal plane at the same straight lines, where $G > K$.

In Simplant, the occlusion plane was adjusted as a horizontal reference. In the horizontal view, at the occlusion plane level, the dental arch was drawn to generate the CT expansion diagram, and the blue line was perpendicular to the dental arch (Fig. 3). On the CT expansion diagram, the section of the blue line was adjusted. On the section perpendicular to the dental arch, widths, heights, intermaxillary distances, and cortical thicknesses of the donor bone were measured at three sites, including the midpoint of the incisal edge (U1), the canine tip (U3), and the mesiobuccal tip (U6) of the first molar. The horizontal distance between the buccal side and tongue side 2 mm below the highest point was regarded as the width of the reconstructed alveolar process [13]. The height of the donor bone was the vertical distance between the upper and lower edges. The intermaxillary distance was the vertical distance between the maxillary tooth tip and the upper edge. The cortical thickness was considered as the thickness at the midpoint of the upper edge

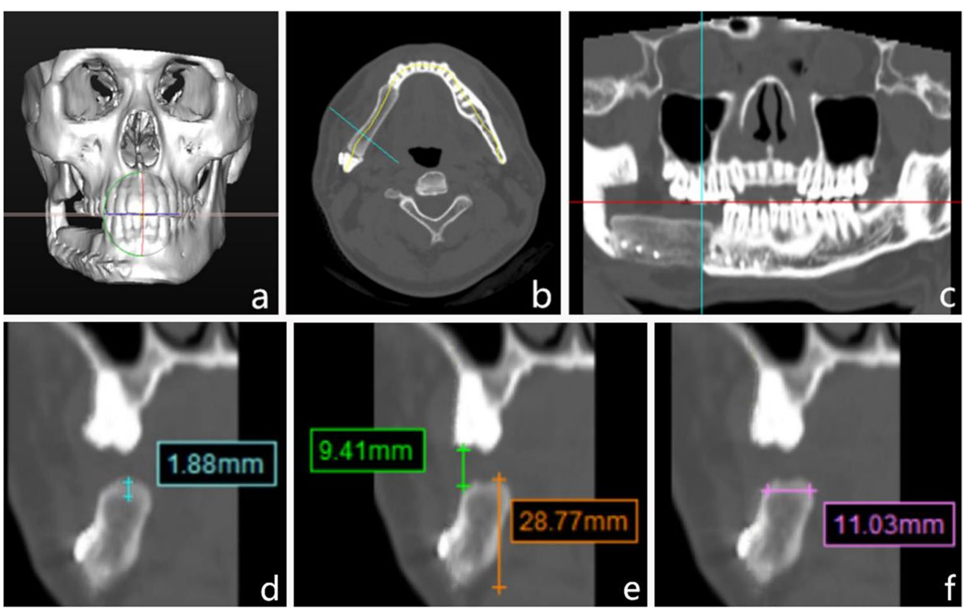


**Fig. 3** Measurement of bone graft. **a** The occlusion plane was adjusted as the horizontal reference; **b** in the horizontal view, at the occlusion plane level, the dental arch was drawn to generate a CT expansion diagram, in which the blue line was perpendicular to the dental arch; **c** on the CT expansion diagram, the blue line was adjusted to through the midpoint of the incisal edge (U1), the canine tip (U3), and the mesiobuccal tip (U6) of the first molar in turn. Measurements were obtained using a screenshot of the corresponding crown position, as shown in the figure: **d** the blue represented cortical thickness; **e** the green and orange represented measurement items of intermaxillary distance, iliac height, respectively; **f** pink represented alveolar bone width

(Fig. 3). In addition, the length of the grafts was measured in both groups, and cases in which the width of the reconstructed alveolar process was less than 6 mm were recorded.

### Statistical analysis

All data analyses were performed using IBM SPSS Statistics version 25.0 (IBM Corp, Armonk, NY, USA). With the supervision and guidance of a senior physician, evaluation and measurement of the research object were completed by a physician. Each site was measured twice, and the time interval between measurement sessions was 1 week. The intraclass correlation coefficient (ICC) was used to evaluate reliability. Intergroup differences in height and asymmetry rate of the bone 1 year after the operation were evaluated using an independent sample *t*-test. The Wilcoxon signed-rank test and Fisher exact probability method were used to compare the width of the alveolar side graft 1 year after the operation in the two groups. The Wilcoxon rank-sum test was used to compare the differences in intermaxillary distance and cortical thickness of the alveolar side 1 year after the operation. The test level was bilateral $\alpha = 0.05$, and *p*-values less than 0.05 were considered significant.

## Results

The study population included 78 patients, with 25 cases in group A and 53 cases in group B (male: female, 1:1.23). The patients' ages ranged from 18 to 77 years (median, 41.3 years). On the basis of the postoperative pathological results, inflammation, trauma, and benign tumors were classified as benign diseases, while malignant tumors were classified as malignant diseases. The types of defects were categorized as L and LC/LCL (Table 1). The stability between the observer groups was good (ICC > 0.75).

In group A, the asymmetry rates at the lower edge of the mental foramen (MF) point, Go point, and LC point were 6.0% ± 1.17%, 8.7% ± 1.25%, and 6.9% ± 1.19%, respectively, and the corresponding values in group B were 10.7% ± 1.81%, 9.5% ± 1.12%, and 6.2% ± 1.06%, respectively. At the lower edge of the MF point, the asymmetry rate of the LC-type defect in group A was less than that in group B ($p < 0.05$). No significant differences was observed between the other points and other defect types.

The bone height at sites U1, U3, and U6 in group A was 27.0 ± 1.19 mm, 27.3 ± 1.16 mm, and 25.54 ± 1.01 mm, respectively, while the corresponding values in group B were 24.5 ± 0.81 mm, 25.1 ± 0.81 mm, and 25.9 ± 0.84 mm, respectively. The two groups showed no significant difference in bone height. The bone length was 46.55 ± 3.35 mm in group A, and the bone length was 48.95 ± 2.93 mm in group B; the results showed that there was no significant difference in the length between group A and group B ($p > 0.05$). The intermaxillary distance in group B at all three measurement points was greater than that the corresponding values in group A. The distance between jaws passing through U3 and U6 sites was significantly different between the two groups ($p < 0.05$) (Fig. 4).

The bone width of the alveolar process side 1 year after bone transplantation was 11.17 ± 0.55 mm, 11.29 ± 0.48 mm, and 11.10 ± 0.36 mm at sites U1, U3, and U6, respectively, and these values were greater than the corresponding values in group B, which were 7.18 ± 0.33 mm ($p < 0.05$), 7.50 ± 0.31 mm ($p < 0.05$), and 8.08 ± 0.30 mm, respectively ($p < 0.05$). The width of the alveolar process side was greater than 6 mm in all cases in group A (Table 2), but it was less than 6 mm in 15 cases in group B ($p < 0.05$).

New bone cortex was formed on the non-iliac crest side 1 year after the operation. The bone cortex thickness in the

**Table 1** The characteristics of patients

| Variable | | Group A (*n*) | Group B (*n*) |
|---|---|---|---|
| Number of patients | 78 | 25 | 53 |
| Age (years), median (range) | | 42.28 (20—74) | 40.80 (18—77) |
| Gender | Male | 10 | 25 |
| | Female | 15 | 28 |
| Disease | Benign | 18 | 38 |
| | Malignant | 7 | 15 |
| Defect | L | 6 | 21 |
| | LC/LCL | 19 | 32 |
| Number of iliac segments | 1 | 10 | 30 |
| | 2 | 15 | 23 |
| Implanting rate | Implanted/overall | 12/25 (48.0%) | 7/53(13.2%) |

Data presented as *n* or percentage; *Group A*, the iliac crest towards alveolar process; *Group B*, the iliac crest towards mandibular inferior margin

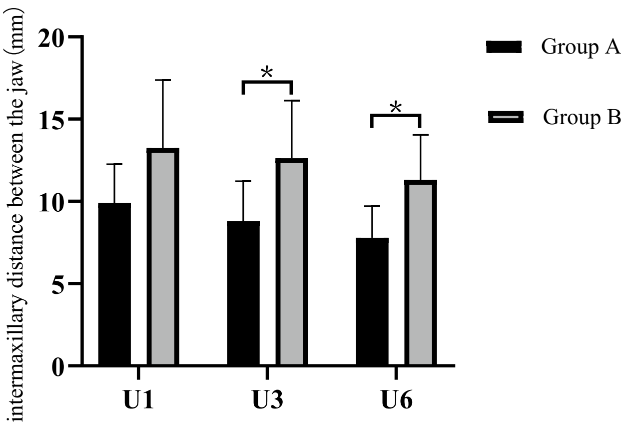


**Fig. 4** Intermaxillary distance of different iliac crest groups at different measurement sites was calculated one year after operation. *UI*, midpoint of the incisor edge; *U3*, the canine tip; *U6*, the mesiobuccal tip of the first molar; *Group A*, the iliac crest towards alveolar process; *Group B*, the iliac crest towards mandibular inferior margin; * statistically significant difference

**Table 2** The number of cases in which the bone width of the alveolar process side in two groups was less than 6 mm one year after the operation

| Group | Group A (*n*) | Group B (*n*) | *p*-value |
|---|---|---|---|
| < 6 mm | 0 | 15 | 0.002* |
| ≥ 6 mm | 25 | 38 | |

Data presented as *n*; *statistically significant difference

**Table 3** Cortical thickness of two groups at different measurement sites 1 year after the operation

| Location | Group A Cortical thickness (mm) | Group B Cortical thickness (mm) | *p*-value |
|---|---|---|---|
| U1 | 1.99 ± 0.12 | 1.37 ± 0.07 | < 0.001*** |
| U3 | 2.17 ± 0.14 | 1.36 ± 0.07 | < 0.001*** |
| U6 | 1.93 ± 0.13 | 1.44 ± 0.07 | < 0.001*** |

Data presented as mean ± SD; ***statistically significant difference

alveolar process side in group B was approximately 1 mm at 1 year after the operation, but it was less than that in group A ($p < 0.05$) (Table 3).

## Discussion

When vascularized bone transplantation is used for jaw reconstruction, the second postoperative implantation is generally performed half a year after the initial operation. Li et al. [14] mentioned that implantation performed 8 months after surgery seemed to have a definite effect in slowing down the absorption of the fibula, and fibula transplantation was stable in the first year after surgery, so we chose to obtain measurements 1 year after surgery.

In this study, the measurement method was not the same as that used in previous measurements of long bones, in which measurements were obtained at equal points [15]. Instead, we considered the position of the complete overdenture implant as a reference [16], and selected three points that were closely related to occlusion to measure the iliac bone, namely, the incisal edge midpoint (U1), the cusp (U3), and the mesiobuccal tip (U6) of the first molar. In combination with clinical needs, these measurements could allow more purposeful and objective evaluation of the ability of the two restoration methods to meet the dental implant conditions 1 year after the operation.

Due to the strengthening or weakening of left- and right-side functions during growth and development, the craniofacial structure of normal people often shows left and right asymmetry, and the physiological asymmetry rate is less than 10%, indicating that the corresponding craniofacial structure has good symmetry [17]. Our results showed that bone symmetry in group A was superior to that in group B. The shape of the mandible is determined by the lower edge of the mandible [18]. When the alveolar process was oriented by the iliac crest, the lower margin of the graft bone was dominated by cancellous bone and titanium plate, which could be adjusted more individually rather than relying on the curvature of the iliac crest itself. In such cases, a preoperative digital design offers a better option for achieving a satisfactory appearance[19]. The research [29] shows that for the traditional surgery relying on the experience of surgeons, digital design can trim the bone mass more accurately and obtain better bone morphology, so digital design is also a factor affecting the shape of bone structure. Due to sufficient bone mass of the iliac, the surgeon could appropriately adjust the iliac bone during the operation to obtain a better shape, which also affects the final appearance after operation. Generally, bone grafts of a certain height are required for postoperative implantation [20, 21]. In this study, the bone height in both groups was greater than 20 mm, which met the bone height requirements for later repair. Thus, the advantage of iliac bone in comparison with the fibula in providing sufficient bone height was obvious [22].

Among the basic requirements for implants, the width of the alveolar process for dental implants should be at least greater than 6 mm or 5–6 mm [23]. The width measurements in the present study showed that in 15 patients, the width in the iliac crest toward mandibular inferior margin was less than 6 mm at three measurement sites, increasing the risk of not meeting the requirements for subsequent implantation. The average width in group B was about 7 mm, which was only slightly larger than the minimum normal implant standard width. If the overbite relationship with the maxilla was poor enough to necessitate adjustment of the implant position to the buccal or lingual side, the insufficient residual bone of the buccal or lingual sides may have influenced the implant effect. However, the average width in group A was about 11 mm. Even if the overbite of the graft position was not ideal, the implant position could be adjusted to ensure 1–2 mm thickness of buccal or lingual bone.

In addition to the requirements for bone height and width, the initial stability of the implant is also important for success, and is related to the thickness of cortical bone [24]. Generally, the cortical bone is required to be 1–1.5 mm thick, because a thick cortical bone above the implant nest can increase the strength of bone-bonding [25]. In this study, new bone cortexes were formed on the non-iliac crest sides in both groups 1 year after surgery, the same as in previous studies [19]. The thickness of the cortical bone in the alveolar process side of group B was less than that in group A. In addition, the time for the formation of a complete and continuous bone cortex on the non-iliac crest side was found to differ between patients.

Blood supply of iliac bone flap is deep circumflex iliac artery, and the vascular pedicle enters from the lower side of the anterior superior iliac crest and feeds the iliac flap [30, 31]. During mandibular reconstruction, if the iliac crest is used to repair the mandibular inferior margin, the ipsilateral iliac bone would be selected. If the iliac crest is used to reconstruct the alveolar process, the contralateral iliac bone must be selected to reconstruction. When the iliac crest is placed toward the alveolar process, the external and internal abdominal oblique muscles attached to the iliac crest can also be used to repair the soft-tissue defect in the oral cavity [26, 27]. This repair will subsequently become mucosa, which is critical for the long-term stability of the bone around the implant [28].

Considering that the mandibular defect in this study did not involve mandibular angle and condyle, which do not belong to the scope of second-stage implantation. It is uncertain whether the iliac crest toward the alveolar process is still superior among the types of mandibular defects mentioned above. And the research results were mainly the bone mass of one year after operation, it is not clear whether the difference between the two groups is more obvious at other time periods after operation. In addition, this study mainly focused on the measurement of implant related parts and did not compare the total volume change of transplanted bone, so the overall trend of bone remodeling between the two groups may not be clear[32]. Considering the current study's limitations, more types of jaw defects, longer follow-up periods, and more accurate research will be required in future studies.

## Conclusions

One year after the operation, Iliac crest towards alveolar process provided a more adequate alveolar crest width, more suitable intermaxillary distance, and more favorable cortical thickness for implant repair than the iliac crest towards mandibular inferior margin. Therefore, reconstruction of the mandible with the iliac crest towards alveolar process may offer a better alternative.

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**Data Availability** All data included in this study are available upon request by contact with the corresponding author.

## Declarations

**Ethical approval** This study has been approved by the Institutional Ethics Committee, Peking University School and Hospital of Stomatology (PKUSSIRB–202060207).

**Informed consent** For this type of study, formal consent is not required.

**Conflict of interest** The authors declare no competing interests.



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