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## Fibular Dimensions for Mandibular Reconstruction among Filipinos

### ABSTRACT

**Objective:** To determine if the anatomic dimensions (length, cross-sectional width, cortical thickness) of the Filipino fibula are ideal for mandibular reconstruction.

#### Methods:

**Design:** Cross-Sectional Study  
**Setting:** Anatomy dissection laboratory  
**Participants:** 40 fibulas from 20 adult cadavers

**Results:** Morphometric examination showed the mean length of the harvested fibulas was 33.5 cm. The mean horizontal (a-d) and vertical (b-c) widths of the proximal cross-section (point B) were  $15.1 \pm 0.28$  mm and  $9.9 \pm 0.15$  mm respectively. The mean horizontal (a-d) and vertical (b-c) widths of the distal cross-section (point D) were  $15.4 \pm 0.24$  mm and  $10.3 \pm 0.49$  mm, respectively. The mean cortical thickness of the anterior (a), lateral (b), posterior (c) and medial (d) aspects of the proximal cross-section (point B) were  $5.2 \pm 0.1$  mm,  $3.2 \pm 0.04$  mm,  $3.6 \pm 0.01$  mm, and  $2.9 \pm 0.06$  mm, respectively. The mean cortical thickness of the anterior (a), lateral (b), posterior (c) and medial (d) aspects of the distal cross-section (point D) were  $5.1 \pm 0.21$  mm,  $3.1 \pm 0.11$  mm,  $3.5 \pm 0.04$  mm, and  $2.9 \pm 0.09$  mm, respectively.

**Conclusion:** Our findings show that the Filipino fibulas studied have dimensions that are ideal for mandibular reconstruction.

**Keywords:** Mandibular reconstruction, Fibula, Free Flaps, Fibular bone dimensions, Filipino

**Over the past years**, the fibular free flap has been considered the workhorse for mandibular reconstruction, having all the ideal features of adequate length, width, bone quantity and quality, and good success rate.<sup>1</sup> In the Philippines, the fibular free flap has been previously described for head and neck reconstruction particularly for segmental mandibular defects and as a condylar autograft since 2005.<sup>2</sup> Although great success has been encountered locally in terms of its survival, evaluation of its dimensions especially for dental restoration remains a challenge.

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To the best of our knowledge, based on a search of MEDLINE PubMed, WPRIM and Google Scholar using the keywords “mandibular reconstruction,” “fibula,” “free flap/s,” and “fibular bone dimensions,” data on the anatomic dimensions of the Filipino fibula has not yet been published to show if it meets ideal dimensions for mandibular reconstruction.

This study aims to determine the suitability of anatomic dimensions of harvested fibulae for mandibular reconstruction in Filipinos in terms of length (cm) from fibular head to the lateral malleolus, cross-sectional width (mm) along pre-determined segments and cross-sectional cortical bone thickness (mm) along pre-determined segments.

**METHODS**

With Institutional Review Board approval, 40 fibulas of 20 formalin-preserved cadavers consisting of 12 males and 8 females located in the Anatomy Dissection Laboratory of the Ateneo School of Medicine and Public Health were harvested and measured. The number of available cadavers determined our sample size.

**Measurement of Fibular Length**

The fibulas were exposed along their length. For each fibula, the apex of the fibular head and apical margin of the lateral malleolus were referred to as ‘A’ and ‘E’, respectively. (Figure 1) The segment A-E was divided into 4 segments. Point ‘C’ was midline and point ‘B’ and ‘D’ were marked 4 cm above and below point ‘C’ corresponding to the standard osteotomy sites in harvesting the fibula for free tissue

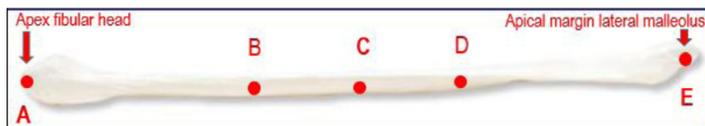


Figure 1. Transverse view of fibula showing segments used as reference

transfer. Measurements were sequentially obtained by two separate observers using a single soft tape measure (TR-13W Tailor’s Tape, The Perfect Measuring Tape Company, Portland, OR, USA) and recorded in millimeters. A single recorded discrepancy above 10mm was verified by re-measurement and consensus before recorded measurements were averaged and tabulated.

**Measurement of Cross-Sectional Width**

Osteotomies were performed on each fibula using a single oscillating saw (Mopec Autopsy Saw, Stryker®, MI, USA) at points ‘B’ and ‘D’ corresponding to the actual osteotomy sites for fibular harvesting. The cross section of the segmentally osteotomized fibula were

marked with points “a”, “b”, and “c” referred respectively as its anterior margin, medial crest and lateral margins. (Figure 2) The mid portion from points “b” and “c” was marked as point “d”. The distance between points “a” and “d” was used to measure the vertical width of the fibular cross section while the distance from points “b” and “c” was used to measure its horizontal width. Measurements of cross-sectional width were sequentially obtained by two separate observers using a single 3.5” Castroviejo caliper (Braun - Aesculap Inc., PA, USA) and recorded in millimeters, averaged and tabulated.

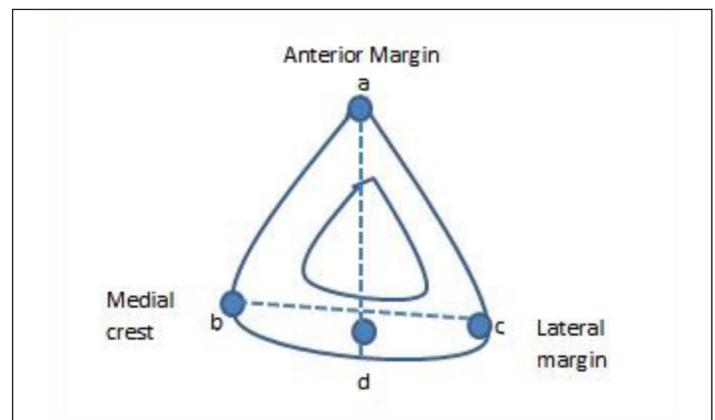


Figure 2. Model showing how cross-sectional width was determined

**Measurement of Cross-Sectional Cortical Bone Thickness**

At points B and D of each fibular segment, cortical bone thickness was sequentially measured by two separate observers using the same caliper at its anterior, lateral, posterior and medial aspects that were respectively marked as points [a], [b], [c], and [d]. (Figure 3)

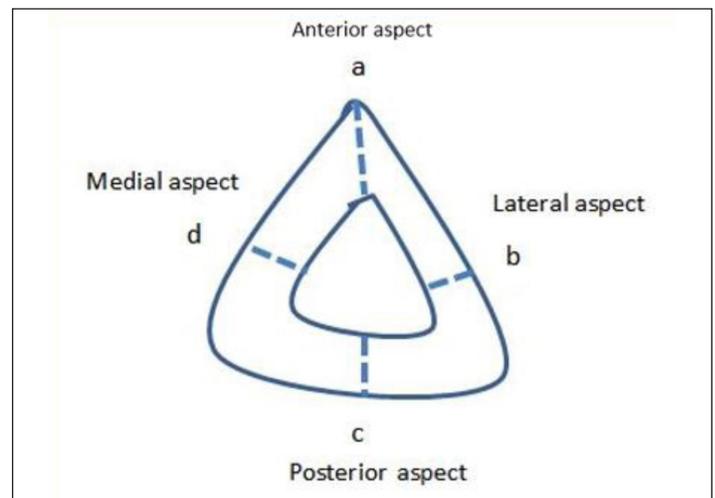


Figure 3. Model showing how cross-sectional cortical bone thickness was determined



### Statistical Analysis

Each distance was separately measured by 2 observers and encoded on MS Excel 2010 (Microsoft Corporation, Redwood WA, USA) for statistical data analysis using percentages, means and standard deviation. Discrepancies in measurements obtained by the two observers were insignificant (sub-centimeter) and simply averaged, except for the previously mentioned readings of fibular length of >10 mm that were re-measured to obtain a consensus.

### RESULTS

Forty fibulas were successfully harvested and measured from 20 cadavers, of which there were 12 males (60 %) and 8 females (40 %) with a 3:2 male to female ratio.

#### Fibular length and cross-sectional width at various segments

The mean length of the harvested fibulas was 33.5 cm. The mean horizontal (a-d) and vertical (b-c) widths of the proximal cross-section (point B) were  $15.1 \pm 0.28$  mm and  $9.9 \pm 0.15$  mm, respectively. The mean horizontal (a-d) and vertical (b-c) widths of the distal cross-section (point D) were  $15.4 \pm 0.24$  mm and  $10.3 \pm 0.49$  mm, respectively. (Figure 2)

#### Thickness of Cortical Bone in Various Cross-Sectional Levels

The mean cortical thickness of the anterior (a), lateral (b), posterior (c) and medial (d) aspects of the proximal cross-section (point B) were  $5.2 \pm 0.1$  mm,  $3.2 \pm 0.04$  mm,  $3.6 \pm 0.01$  mm, and  $2.9 \pm 0.06$  mm respectively. The mean cortical thickness of the anterior (a), lateral (b), posterior (c) and medial (d) aspects of the distal cross-section (point D) were  $5.1 \pm 0.21$  mm,  $3.1 \pm 0.11$  mm,  $3.5 \pm 0.04$  mm, and  $2.9 \pm 0.09$  mm, respectively. (Figure 3)

### DISCUSSION

The osteocutaneous fibula free flap (OFFF) presents numerous advantages. The bony architecture is similar to that of the mandible, which on cross section shows a marble-like bone structure of thick compact layer giving an excellent anchorage for dental implants unlike iliac crest or scapula.<sup>3</sup> The fibula also shows similarity to mandibular width and shape, and this also facilitates the insertion of dental implants. A study by Huryn *et al.*<sup>4</sup> showed that fibula free flaps behave like an edentulous mandible. Thus, osseointegration can generally be expected. The grafts can easily be adjusted to the curvature of the mandible using osteotomy or the intersection technique. Owing to its extensive vascular network, the diaphysis of the fibula can be osteotomized into different segments without danger of necrosis.

Germain *et al.*<sup>5</sup> reported that the fibula can provide up to 25 cm of bone for harvesting and it is necessary to preserve 6 – 7 cm of bone distally and proximally to maintain the integrity of the knee and ankle joint. Uchiyama *et al.*<sup>6</sup> showed that it is necessary to preserve at least 6 cm of bone and that the distal fibula is responsible for stabilizing the ankle mortise during external rotation and inversion.

The fibula is a long thin non weight-bearing bone of the lower extremity. Frodel *et al.*<sup>7</sup> measured the height and weight of the fibula and the cortical thickness in transverse cross sections. It is one of the strongest bones available for transfer due to its tubular shape with thick cortical bone around the entire circumference.<sup>7</sup>

Analysis of our data suggests that the Filipino fibulas sampled have adequate length for mandibular reconstruction. The average length was noted to be 33.5 cm. Sparing the necessary 6 cm (proximally and distally) to retain stability of the knee and ankle joint would still leave 21.5 cm of bone for mandibular reconstruction. A study by Apinhasmit *et al.*<sup>8</sup> showed mean total fibular length and mean length of harvested fibulae were  $34.2 \pm 2.3$  cm and  $18.2 \pm 2.3$  cm, respectively. A harvested fibula of 16 to 20 cm in length is sufficient to provide bone for reconstructing mandible defects.<sup>8</sup>

The fibulas were also noted to have a cross-sectional width of no less than 8 mm with the greatest diameter at segment a-d (15.4 mm). This was consistent with the study by Matsuura *et al.*<sup>9</sup> where segment a-d was the longest in cross sections at C, D and E. The a-d segment or the anterior margin of the fibula is often used to reconstruct the alveolar crest and the lateral surface of the fibula or the b-c segment is used to reconstruct the labiobuccal aspect. These findings should be useful for mandibular reconstruction.

In our study, the greatest cortical thickness was noted to be 6.5 mm with a mean of 5.2 mm at point a. This is again consistent with the study of Matsuura *et al.*<sup>9</sup> which showed the greatest cortical thickness at apex a (4.1 mm). This is useful for osseointegrated implants, considering that osseointegrated implants have a width of 4 mm, the fibula then has adequate cortical bone to surround the implant for better stability and thus success of the osseointegration.<sup>10</sup>

The use of osseointegrated implants restores both function and aesthetics. According to Anne-Gaelle *et al.*,<sup>11</sup> the success rate for osseointegration ranges from 86% to 99%. Mandibular reconstruction by microvascular fibula free flap has dramatically improved the quality of life of patients treated by surgery.

The OFFF has its limitations. Because of its limited height (rarely more than 15 mm) compared with the height of the mandible, vertical distance between the reconstructed segment and the occlusal plane can be substantial. To address this, Choo-Lee *et al.*<sup>12</sup> showed that vertical



distraction osteogenesis of free vascularized flaps is a reliable technique that optimizes implant positioning for ideal prosthetic rehabilitation, after mandibular reconstruction following tumor surgery.

Despite the sample size limitation imposed by the availability of cadavers, our study shows that the anatomic dimensions (length, cross-sectional width, cortical thickness) of the Filipino fibulas studied are sufficient for mandibular reconstruction. However, the sample of cadavers dissected may not be representative of the larger Filipino population, limiting the generalizability of our findings. Subsequent studies that are more representative may be more generalizable.

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