

Measurements of Talus for Sizing Talar Body Prosthesis

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Abstract

Background: Talar body prosthesis insertion is an option for preserving the function of the ankle and foot that suffers from avascular necrosis of talus. However, talus size varies between individuals. Knowledge of the dimensions and the curve angles of the talus is necessary for sizing talar body prosthesis.

Objective: To measure the dimensions and the curve angles of the talus

Design: Cadaveric study

Material & Methods: Fifty-seven pairs of tali were harvested from 57 adult cadavers and cleaned of soft tissue around the talus. Talar body, neck and posterior facet were measured in terms of dimensions and curve angles.

Result: Measurements of the left tali showed that the average anterior and posterior widths of the talar dome were 27.09 mm (SD 1.89) and 19.69 mm (SD 1.73) respectively. The vertical inclination angle of the medial and the lateral surfaces were 100.45 (SD 5.56) and 96.04 (SD 4.41) respectively. The anteroposterior inclination angles of the medial and the lateral borders of the talar dome were 4.79 (2.76) and 7.99 (SD 4.49) respectively. The depths of the anterior end and posterior third of trochlear were 1.33 mm (SD 0.32) and 0.63 mm (SD 0.43) respectively. The curve angles of the anterior and the posterior third of the trochlear were 174.64 (SD 5.61) and 174.72 (SD 5.49) respectively. The curve angle of the medial and the lateral talar dome were 129.20 (SD 7.56) and 124.660 (SD 9.49) respectively. The thickness was 23.95 mm (SD 1.73). The length, width, depth and curve angle of the posterior facet were 28.51 mm (SD 1.97), 18.17 mm (SD 1.59), 6.32 mm (SD 0.89) and 134.19 (SD 5.74) respectively. The angle between the long axis of the posterior facet and the long axis of the talar body was 49.25 (SD 5.38). The length, width and thickness of the left talar neck were 23.65 mm (SD 1.89), 26.14 mm (SD 2.13) and 22.43 mm (SD 1.80) respectively. The corresponding figures for the right talus were 27.47 mm (SD 2.03), 19.12 mm (SD 1.30), 99.57 (SD 6.78), 96.45 (SD 5.03), 4.25 (SD 4.09), 6.76 (SD 3.15), 1.37 mm (SD 0.56), 0.65 mm (SD 0.44), 167.04 (SD 4.10), 174.72 (SD 5.49), 129.39 (SD 5.53), 119.16 (SD 7.96), 24.06 mm (SD 2.03), 28.51 mm (SD 2.52), 18.33 mm (SD 2.01), 6.30 mm (SD 0.95), 133.51 (SD 5.03) 47.26 (SD 5.93), 23.83 mm (SD 2.00), 26.13 mm (SD 2.39) and 22.59 mm (SD 1.91) respectively. Statistical analysis showed no significant difference in the dimensions and the curve angles of the left and right tali. But female talus is significantly smaller than male talus.

Conclusion: There is no significant difference between the left and right tali in terms of dimensions and curve angles. Female talus is smaller than male.

Relevance: Knowledge of the values of the measurements can be applied for sizing talar body prosthesis.

The treatment of avascular osteonecrosis of the talar body by ankle arthrosis^{1,3} causes severe disability of the ankle and foot. Harnroongroj⁴ has designed and developed talar body prosthesis to replace the body of talus in order to preserve ankle and foot functions. However, the prosthesis is not available in various sizes, so the appropriate size of the prosthesis is estimated by measuring the opposite talus and the prosthesis is then made individually.² Talus varies in size which depends on individuals.⁷ In order to provide various sizes of talar body prostheses for surgery, measurements of the dimensions and the curve angles of talus are necessary for sizing talar body prosthesis.

MATERIALS & METHODS

Fifty-seven pairs of tali were harvested from 57 cadavers, 22 males and 35 females, with age ranging

from 32 to 96 years old. The soft tissue around the talus was removed by boiling technique. Measurements were performed by using a digital vernier caliper (Tesa, Swiss) and a goniometer 990 (QI.n.cq, USA)

The talar body was measured as follows: the anterior and posterior width of the talar dome (Figure 1), the vertical inclination of the medial and lateral surfaces (Figure 2), the anteroposterior inclination of the medial and lateral border of the talar dome (Figure 3), the depth and the curve angle of the trochlear at the anterior end of the articular cartilage and the posterior third of the talar dome. (Figure 4) The curve angle of the medial and lateral talar dome (Figure 5), and the thickness (Figure 6) were also measured. The posterior facet of the talus was measured as follows: the length (Figure 7A), the width (Figure 7B), the depth (Figure 7C), the curve angle (Figure 7D) and the angle between the long axis of the posterior facet and the

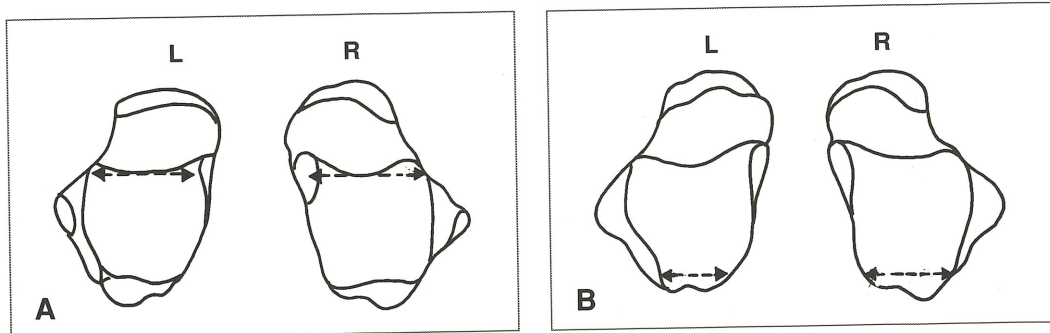


Fig. 1 Measurements of the talar dome

- A The anterior width of the talar dome was measured as a distance of a line starting from the anterior end of the lateral articular cartilage at right angle to the long axis of the talar body to the medial aspect of the talar dome.
- B The posterior width of the talar dome was measured as a distance of a line starting from the posterior end of the articular cartilage of the medial aspect of the talar body at right angle to the long axis of the talar body to the lateral aspect of the talar dome.

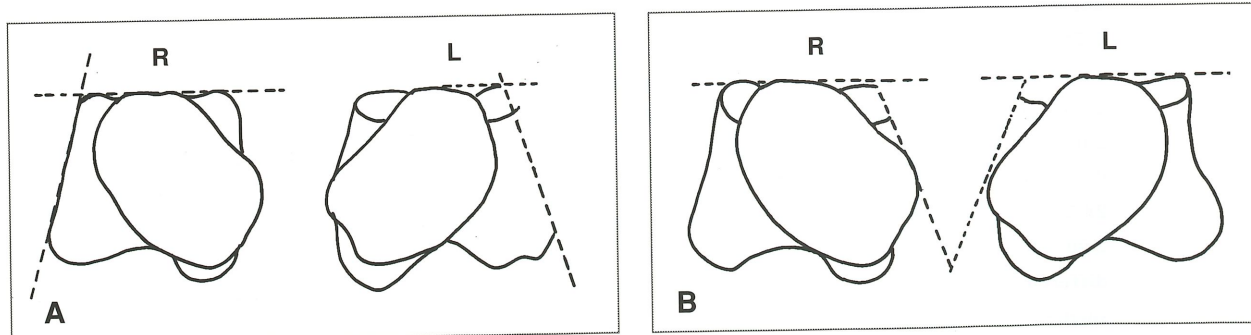


Fig. 2 The vertical inclination of the lateral and medial surfaces of the talar body were measured as angles in relation to the superior surface of the talar dome.

- A The vertical inclination of the lateral surface was measured as the angle that the line which starts from the top of the talar dome along the lateral surface made with the superior surface of the talar body.
- B The vertical inclination of the medial surface of the talar body. The angle was measured as the angle that the line which starts from the top of the talar dome along the medial surface made with the superior surface of the talar body.

long axis of the talar body (Figure 7E). The talar neck was measured as follows: the length (Figure 8A), the thickness (Figure 8B) and the width (Figure 8C). Since the measurements of the depth and the curve angle are difficult to performed directly on the talus by

the vernier caliper or the goniometer, acrylic cement was applied to the surface area to be measured to make a mold. The acrylic mold was then removed, cut longitudinally to provide a smooth surface, and used as a template for indian ink printing on a piece of paper.

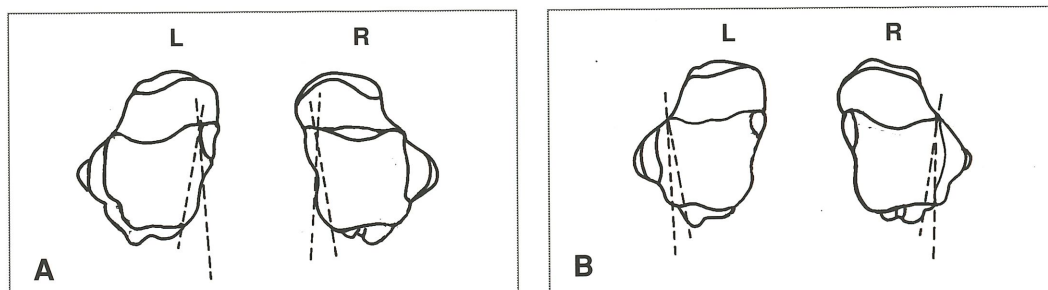


Fig. 3 Measurements of the anteroposterior inclination of the medial and the lateral talar dome.

- A The anteroposterior inclination of the medial border of talar dome was measured as the angle that the line along the medial rim of the talar dome made with the long axis of the talar body.
- B The anteroposterior inclination of the lateral border talar dome. The angle was measured as the angle that the line along the lateral rim of the talar dome made with the long axis of the talar body.

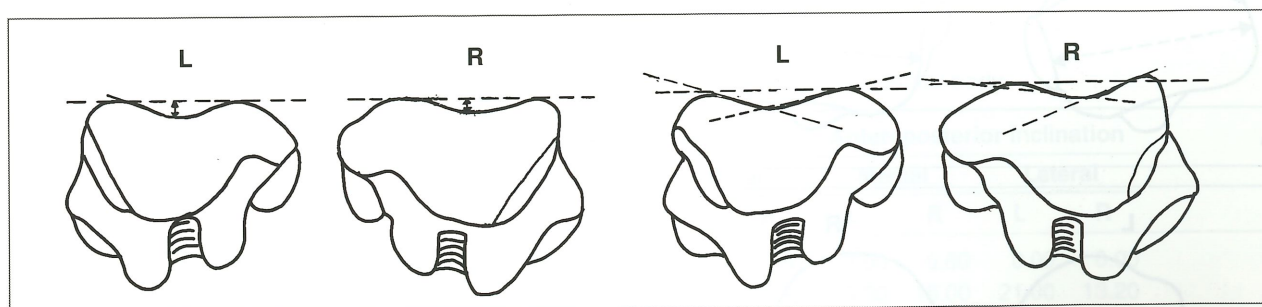


Fig. 4 The depth and the angle of the trochlear were measured at the anterior end of the articular cartilage and at the posterior third of the talar dome.

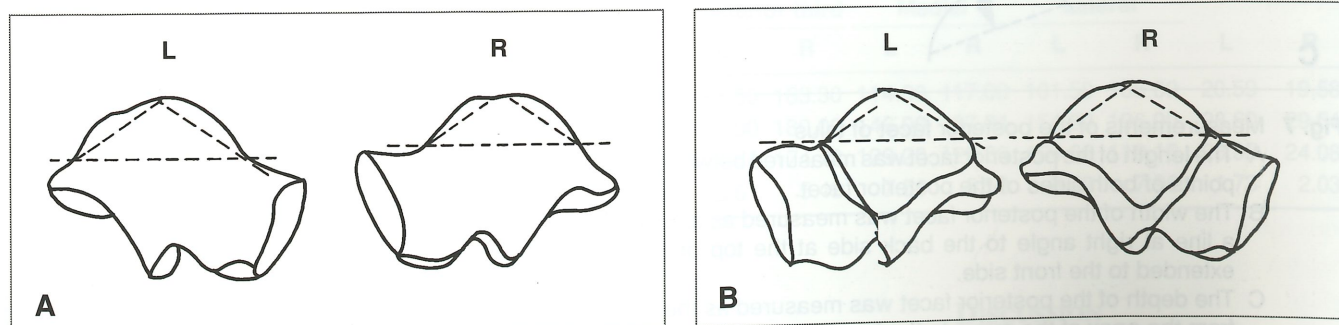


Fig. 5 Measurements of the curve angles of the talar dome

- A The curve angle of the medial talar dome was measured as the angle that the line which starts at the top of the talar dome to the anterior end of the medial articular cartilage of the talar dome made with the line from the top of the talar dome to the posterior end of the medial articular cartilage of the talar dome.
- B The curve angle of the lateral talar dome was measured as the angle that the line which starts at the top of the talar dome to the anterior end of the lateral articular cartilage of the talar dome made with the line from the top of the talar dome to the posterior end of the lateral articular cartilage.

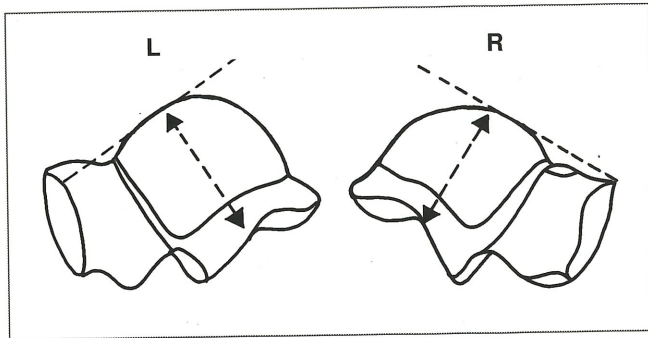


Fig. 6 The thickness of the talar body was measured from the top of the trochlear groove to the apex of the posterior facet curve.

The measurement was done on the printed picture. Other measurements were done directly on the talus by the vernier caliper or the goniometer. All measurements of the talus were made by 2 surgeons. The measured values were recorded and calculated for the mean and the standard deviation, and analyzed the difference between the right and left sides and between female and male.

RESULTS

The results are shown in Tables 1-3.

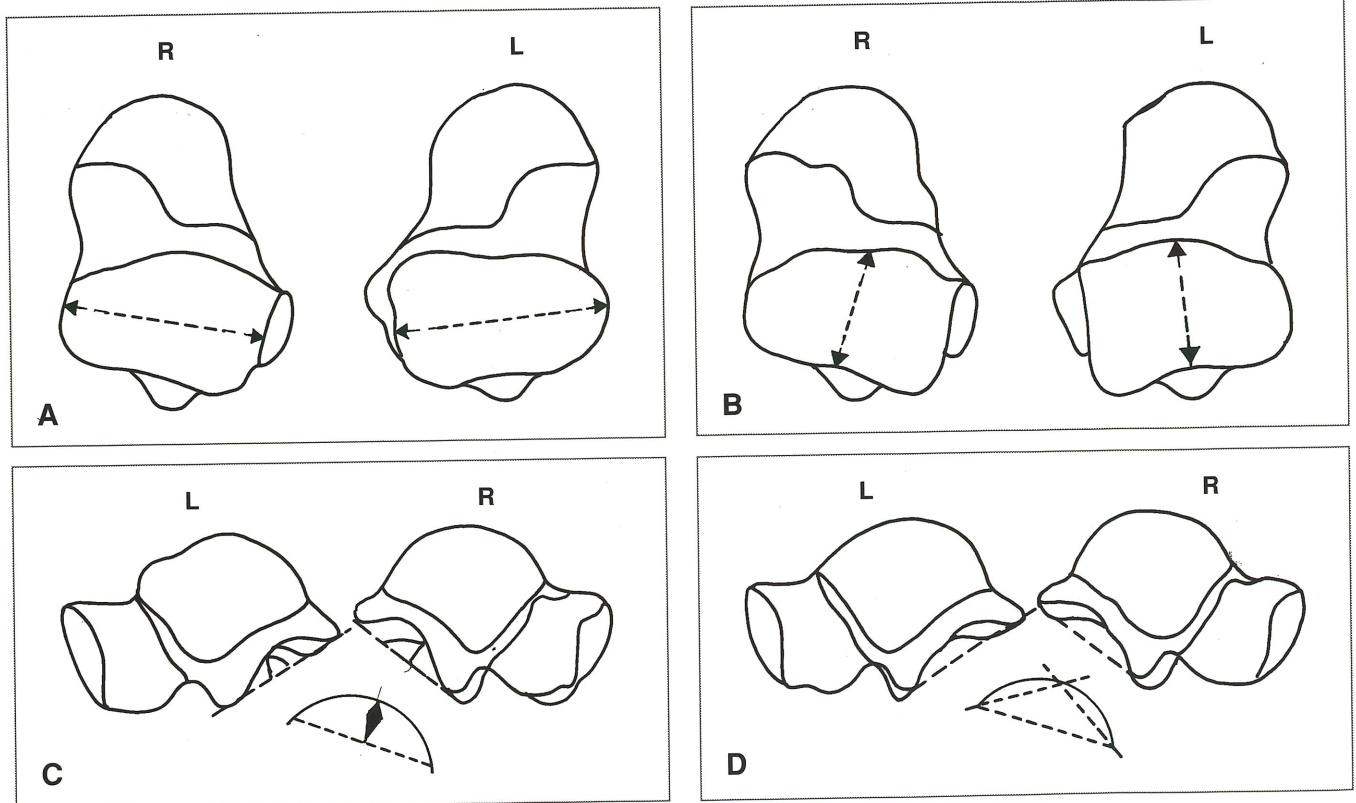
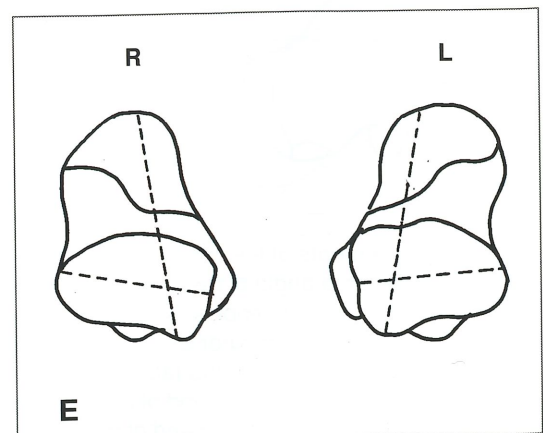


Fig. 7 Measurements of the posterior facet of talus

- A The length of the posterior facet was measured between the mid-points of both sides of the posterior facet.
- B The width of the posterior facet was measured as a distance of a line at right angle to the back side at the top of the curve extended to the front side.
- C The depth of the posterior facet was measured as the distance from the apex of the curve to the base.
- D The curve angle of the posterior facet was measured as the angle made by the two lines from the apex of the posterior facet curve to both sides of the posterior facet.
- E The angle between the long axis of the posterior facet and the long axis of the talar body was measured as the angle that the line between the midpoints of both sides of the posterior facet made with the line along the trochlear groove.



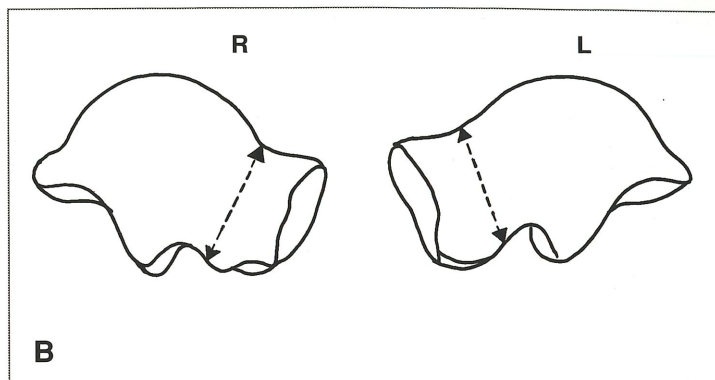
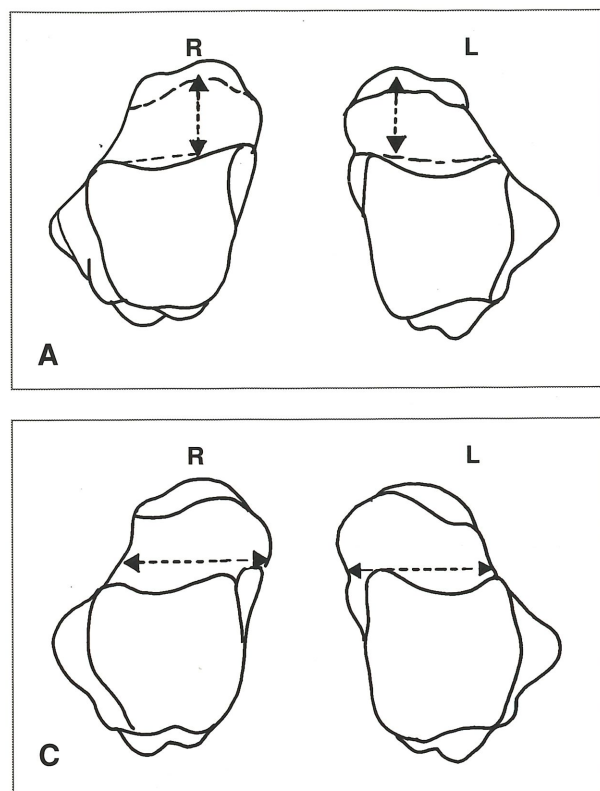


Fig. 8 Measurements of the talar neck

- A The length of the talar neck was measured as the distance between the anterior end of the articular cartilage of the talar dome and the anterior end of the neck.
- B The thickness of the talar neck was measured as the distance between the anterior facet of the talus and the superior surface of the talar neck.
- C The width of the talar neck was measured as the distance between the medial and the lateral aspects of the talar neck.

Table 1 Dimensions (mm) and curve angles (degrees) of talar body

	Width				Vertical inclination				Anteroposterior inclination			
	Anterior		Posterior		Medial		Lateral		Medial		Lateral	
	L	R	L	R	L	R	L	R	L	R	L	R
Minimum	21.43	22.96	16.99	17.04	90.00	90.00	86.80	86.60	3.00	0.60	0.00	0.00
Maximum	31.66	32.31	27.02	22.06	111.50	125.07	109.30	107.80	13.00	15.00	21.00	13.20
Average	27.09	27.47	19.69	19.12	100.45	99.57	96.04	96.43	4.79	4.25	7.99	6.76
SD	1.89	2.03	1.73	1.30	5.56	6.78	4.41	5.03	2.76	4.09	4.49	3.15

	Depth of trochlear				Curve angle of trochlear				Curve angle of talar dome				Thickness	
	Anterior end		Posterior third		Anterior end		Posterior third		Medial		Lateral		L	R
	L	R	L	R	L	R	L	R	L	R	L	R		
Minimum	0.65	0.00	0.00	0.00	161.00	159.00	161.00	163.30	114.00	117.00	101.50	106.00	20.59	19.58
Maximum	1.99	2.18	1.87	1.50	173.00	180.00	180.00	180.00	146.00	137.01	154.60	136.90	28.60	29.54
Average	1.33	1.37	0.63	0.65	167.00	167.04	174.64	174.72	129.20	129.39	124.66	119.16	23.95	24.08
SD	0.32	0.56	0.43	0.44	3.18	4.10	5.61	5.49	7.56	5.53	9.49	7.96	1.73	2.03

Statistical analysis showed no significant difference in all measurements between the right and left sides of the tali ($P < 0.05$). Female talus was smaller than male talus in all dimensions measured ($P < 0.05$) except the curve angles which were not significantly different ($P > 0.05$). The Interobserver reliability test yielded 0.92 inter-correlation coefficient.

DISCUSSION

Avascular necrosis of the talar body is a serious complication of the fracture of the neck and the body of talus^{2,5,8} and causes severe disability of the ankle and foot. The treatment of this serious complication is the arthrodesis of the ankle.^{1,3} To preserve the function of

Table 2 Dimensions (mm) and curve angles (degrees) of the posterior facet

	Length		Width		Depth		Curve angle		Angle with long axis of talar body	
	L	R	L	R	L	R	L	R	L	R
Minimum	22.26	23.23	14.01	14.05	4.28	4.15	120.50	122.40	33.50	31.00
Maximum	32.26	33.23	21.48	21.98	8.11	8.10	148.00	142.80	59.50	62.00
Average	28.51	28.51	18.17	18.33	6.32	6.30	134.19	133.51	49.25	47.26
SD	1.97	2.52	1.59	2.01	0.89	0.95	5.74	5.03	5.38	5.93

Table 3 Dimensions of talar neck

	Length		Width		Thickness	
	L	R	L	R	L	R
Minimum	20.49	20.30	21.62	22.30	18.59	19.26
Maximum	28.50	28.10	29.83	31.80	26.30	28.01
Average	23.65	23.83	26.14	26.13	22.43	22.59
SD	1.89	2.00	2.13	2.39	1.80	1.91

the ankle and foot, Harnroongroj^{4,6} has designed and developed a talar body prosthesis, since 1974, for replacing the avascular osteonecrosis of the talar body. The results of the insertion of the talar body prosthesis have been followed for more than 25 years, showing satisfactory ankle and foot functions. However, the problem of the talar body prosthesis was that a prosthesis is made for an individual by measuring the opposite talus. So, the measurement of the dimensions and curve angles of the talus were necessary for sizing the talar body prosthesis.

The measurements of the talar dimensions and curve angles were performed directly on the cadaveric tali or on the acrylic mold by a vernier caliper and a goniometer which are different from the measurement on a radiograph or CT scan. When the acrylic mold was set, it provided a stable shape so that the results of the measurements of the dimensions and the curve angles of the talus were appropriate for sizing the talar body prosthesis. Statistical analysis showed that the measurements were reliable because the intercorrelation coefficient was more than 0.90. The size of the female talus is smaller than that of male talus, but all angle measurements were not significantly different between female and male. This means that the size of the female talus is smaller but the shape is not different from that of male talus, so there is no problem in making the shape of the talar body prosthesis for

female and male, but a smaller talar body prosthesis should be selected for female.

The results of the measurements showed that the mean size of the talar body prosthesis should be 27 mm wide anteriorly and 23 mm thick. The mean size of the posterior facet of the talar body prosthesis should be 28 mm long, 18 mm wide, and 6 mm deep, and the angle between the axis of the posterior facet and the axis of the talar body should be 47 degrees. The stem for inserting into the talar neck for all sizes of the talar body prosthesis should be 10 mm long and 6 mm wide. Five prosthesis sizes should be produced, with two smaller sizes and two large sizes than the mean prosthesis size. The size increases or decreases in 1 mm step from the size of the mean prosthesis. Moreover, the prostheses of all sizes should have the same curve angles as that of the mean size.

REFERENCES

1. Blair HC. Comminuted fracture and fracture-dislocations of the body of the astragalus: operative treatment. *Am J Surg* 1943; 59: 37-43.
2. Canale ST, Kelly FB Jr. Fracture of the neck of the talus: longterm evaluation of seventy-one cases. *J Bone Joint Surg* 1978; 60A: 143-56.
3. Dennis MD, Tullos HS. Blair tibiotalar arthrodesis for injuries to the talus. *J Bone Joint Surg* 1980; 62A: 103-7.
4. Harnroongroj T, Vanadurongwan V. The talar body prosthesis. *J Bone Joint Surg Am* 1997; 79-A: 1313-22.
5. Hawkins LG. Fractures of the neck of the talus. *J Bone Joint Surg Am* 1970; 52-A: 991-1002.
6. Heckman JD. Fracture of talus. In: Bucholz RW, Heckman JD, editors. *Rockwood and Green's fractures in adults*. 5th ed. Philadelphia: Lippincott; 2001. p. 2117-20.
7. Shahan KS. Osteology. In: Shahan KS, editor. *Anatomy of the foot and ankle*. Philadelphia: Lippincott; 1983. p. 43-54.
8. Sneppen O, Christensen SB, Krogsoe O, et al. Fracture of the body of the talus. *Acta Orthop Scand* 1977; 48: 317-24.