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RESEARCH ARTICLE

ANTHROPOMETRY OF THE LATERAL MALLEOLUS

[1]Raza SMG, [1*]Raza HKT and [1]Upadhyay Sachin

Department of Orthopaedics, Traumatology and Rehabilitation, N.S.C.B Medical College Jabalpur - 482003 MP India

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ABSTRACT

Management of lateral malleolar fractures have gained a lot of attention in recent times. The restoration of proper tilt and length of the lateral malleolus has been a focus for much discussion.. However, there is a current paucity of literature on the contours of the lateral surface of the lateral malleolus as well as its length. The current study was undertaken by studying the contour of the lateral surface of lateral malleolus in antero-posterior and 15 degree internal rotation radiographs of twenty adult volunteers. Length of the lateral malleolus was measured from level of tibial plafond in these radiographs as well as in twenty cadaveric fibulae. This study has provided new data on the contour of the lateral surface of lateral malleolus as well as the fibular length. It is hoped that this will be helpful in designing of pre-contoured plates for lateral malleolar fractures. We also recommend the measurement of lateral fibular length in radiographs of opposite uninjured limb for assessment of restoration of lateral malleolar length.

INTRODUCTION

Ankle fractures have shown an exponential increase in incidence due to the high speed motorcycles on the roads. Better understanding of the mechanism of injury, and the displacements of the components: the lateral malleolus, the talus and the medial malleolus has resulted in better management of these injuries. There is a current debate on the importance to be accorded to the lateral malleolus for operative management of bi-malleolar fractures. Yablon *et al* ,1977 focused on the key role of the lateral malleolus in displaced fractures of the ankle based on laboratory studies on ankles from fresh cadavers and studies on fifty three patients of abduction – external rotation injuries of the ankle. Other workers especially Joy *et al*, 1974 and Pettrone *et al* 1983 also pointed out that proper reduction of lateral malleolus is important. De Souza *et al*, 1985 made a significant contribution by their appreciation of the lateral bend of the lateral malleolus.

There has also been an increased interest for changes in fibular length due to the description of Talo-crural angle by Isman & Inman ,1968, and Sarkisian and Cody 1976.

With techniques of use of Pre-contoured, or plates contoured per-operatively, there is a need for proper data of the bend of the lateral malleolus as well as length of the lateral malleolus. The current study has been undertaken with the purpose of collecting data on various parameters of the lateral malleolus by studies on cadaveric fibulae, and on antero-posterior and mortise view radiographs of volunteers.

MATERIAL AND METHODS

The study was carried out in three parts.

1. Gross measurements of the lateral malleolus in twenty intact cadaveric fibulae from a collection of more than forty (Fig.No.1). All measurements were made with Vernier calipers.

Figure 1 Intact Cadaveric fibulae

Corresponding author:* **Raza HKT
Department of Orthopaedics, Traumatology and Rehabilitation, N.S.C.B Medical College Jabalpur -482003 MP India

A. Length of the lateral malleolus (as measured from top of facet for Talus to the malleolar tip). (Fig. No.2).

Figure 2 Technique for measuring Length of Lateral malleolus

B. Width in sagittal plane (roughly at the middle of the facet for talus). (Fig.No.3)

Figure 3 Technique to measure using Vernier Calipers the sagittal width of Lateral Malleolus.

C. Width in coronal plane (roughly at the middle of the facet for talus). (Fig.No.4).

Figure 4 Technique to measure using Vernier Calipers the Coronal Width of Lateral Malleolus.

2. Radiographs of lower one-third of 20 cadaveric fibulae in antero-posterior view. For proper maintenance of correct anatomical position on the x-ray plate plasticin was used for avoiding rotation of the fibulae (Fig.No.5).

Figure 5 Showing Fibulae on the X-ray cassette fixed with plasticin

3. Antero posterior and 15 degree internal rotation radiographs of the ankle on both sides of twenty volunteers.

The following angles were measured in the antero posterior radiographs of lateral malleolus of cadaveric fibulae/as well as on the radiographs of volunteers. (Fig.No.6,7,8).

A. ***Angle A:*** Drawn on the lateral bend seen over the lateral cortex of lateral malleolus.
B. ***Angle B:*** Drawn on the downward bend seen over the lateral cortex of lateral malleolus.
C. ***Angle C:*** Drawn on the medial bend towards the malleolar tip seen over the lateral cortex of lateral malleolus.

Figure 6 Showing the angles drawn on lateral border of Lateral Malleolus in Neutral AP view

Figure 7 Various angles along the lateral cortex of lateral malleolus (angles A, B, C)

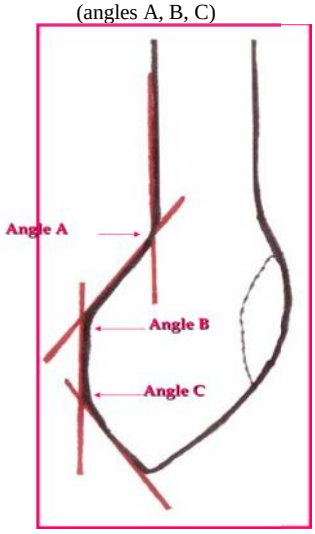

Figure 8 Diagrammatic representation of angles

Table 1

LENGTH (mm)	RIGHT	LEFT	COMBINED
MIN	21	20	20
MAX	28	25	28
MEAN	23.7	23.7	23.6
MODE	25	25	25
MEDIAN	23.5	23.5	24
SD	2.2	2.2	1.87

Observations

Cadaveric study

1. **Lateral Malleolus:** There were 10 fibulae of right side and 10 fibula of left side.

Gross measurements

1. **Length of the lateral malleolus. (**As measured from top of facet for Talus to the malleolar tip)

The maximum length of lateral malleolus as measured from top of facet for talus to the tip of lateral malleolus was 28mm, while the minimum length was 20mm, the average being 23.7mm.

Maximum coronal width of the lateral malleolus (roughly at the middle of the facet for talus as the facet is convex from above downwards)

Table No.2

Width coronal(mm)	Right	Left	Combined
MIN	15	15	14
MAX	23	19	23
MEAN	18.0	16.9	17.45
MODE	19	17	19
MEDIAN	18	17	17
SD	2.3	1.6	1.98

The maximum width of the lateral malleolus (coronal width) was found to be 19mm, while the minimum was 15mm, with an average of 17.5mm.

Maximum Sagittal width of the lateral malleolus (roughly at the middle of the facet for talus).

Table No. 3

Width sagital(mm)	Right	Left	Combined
MIN	21	21	21
MAX	25	25	25
MEAN	23.5	22.9	23.3
MODE	24	23	23
MEDIAN	24	23	23
SD	1.5	1.2	1.36

The maximum sagittal width of the lateral malleolus was found to be 25mm, while minimum was 21mm, with an average of 23.2mm.

Radiographic Assessment :(Measurements in AP view 0^0.)

Angle A': (Drawn on the lateral bend seen over lateral border of lateral malleolus)

Table No. 4

Angle a	Right	Left	Combined
MIN	6	11	6
MAX	19	20	20
MEAN	12.00	15.50	13.75
MODE	14	16	14
MEDIAN	13	16	14
SD	3.94	2.84	3.79

The maximum angle measured was 20^0, minimum angle was 6^0, with an average of 17.45^0.

Angle B': (Drawn on the downward bend seen over the lateral border of lateral malleolus.)

Table No. 5

Angle b	Right	Left	Combined
MIN	2	2	2
MAX	12	17	17
MEAN	6.90	7.80	7.35
MODE	8	2	2
MEDIAN	8	7	8
SD	3.41	6.30	4.9

The maximum angle measured was 17^0, minimum angle was 2^0, with an average of 7.35^0.

Angle C': (Drawn on the medial bend towards the malleolar tip seen over the lateral border of lateral malleolus.)

Table No. 6

Angle c	Right	Left	Combined
MIN	29	19	19
MAX	47	43	47
MEAN	38.80	28.40	33.6
MODE	40	23	40
MEDIAN	39.5	29.5	33
SD	5.67	7.53	8.4

The maximum angle measured was 47^0, minimum angle was 19^0, with an average of 33.6^0.

B. Anteroposterior radiographs in zero degree rotation and 15 degree in internal rotation.

Lateral Malleolus Angles

Angle A' :(Angle drawn on the lateral bend seen over lateral border of lateral malleolus on ankle radiograph.)

Angle B': (Angle Drawn on the medial bend towards the malleolar tip seen over the lateral border of lateral malleolus on the ankle radiographs.)

The maximum Angle B' measured was, AP 0^0 is 25^0 and 15^0 IR is 26^0
Minimum Angle B' measured was ; AP 0^0 ; 30^0 and 12^0 IR ; 10^0

The average was;AP 0^0 ; 18.7^0 and 15^0 IR ; 20.55^0

Angle C': (Angle Drawn on the medial bend towards the malleolar tip seen over the lateral border of lateral malleolus on the ankle radiographs.)

The maximum Angle C' measured was ; AP 0^0; 45^0 and 15^0 IR; 50^0
Minimum Angle C'measured was ; AP 0^0 ; 19^0 and 15^0 IR ; 22^0
The average was ; AP 0^0 ; 32.5^0 and 15^0 IR ; 32.65^0

Table No. 7

Angle a'	Right		Left		Combined	
	Antero posterior (neutral)	Internal rotation in 15 degree	Antero posterior (neutral)	Internal rotation in 15 degree	Antero posterior (neutral)	Internal rotation in 15 degree
MIN	8.0	10.0	8.0	10.0	8	10
MAX	21.0	22.0	21.0	22.0	21	22
Mean	15.40	16.25	17.15	17.10	16.2	16.6
Mode	18	18	17	18	17	18
Median	17.00	17.00	18.00	18.00	17	17
SD	3.87	3.95	3.60	3.18	3.1	3.5

Table No. 8

ANGLE B'	Right		Left		COMBINED	
	Antero posterior (neutral)	Internal rotation in 15 degree	Antero posterior (neutral)	Internal rotation in 15 degree	Antero posterior (neutral)	Internal rotation in 15 degree
MIN	12.0	18.0	12.0	10.0	12	10
MAX	25.0	25.0	25.0	26.0	25	26
Mean	18.35	21.45	19.05	19.65	18.7	20.55
Mode	18	22	18	22	18	22
Median	18.00	22.00	19.00	19.50	18	21
SD	3.86	2.01	3.25	4.18	3.5	3.3

Table No. 9

ANGLE C'	Right		Left		COMBINED	
	Antero posterior (neutral)	Internal rotation in 15 degree	Antero posterior (neutral)	Internal rotation in 15 degree	Antero posterior (neutral)	Internal rotation in 15 degree
MIN	19.0	22.0	20.0	22.0	19	22
MAX	45.0	50.0	45.0	50.0	45	50
Mean	29.70	31.55	35.35	33.75	32.5	32.65
Mode	21	22	38	22	38	22
Median	29.00	31.50	37.00	34.00	36	32
SD	8.37	8.44	7.92	8.47	8.5	8.4

Table No. 10

Length of Lateral Malleolus(mm)	Right		Left		COMBINED	
	Antero posterior (neutral)	Internal rotation in 15 degree	Antero posterior (neutral)	Internal rotation in 15 degree	Antero posterior (neutral)	Internal rotation in 15 degree
MIN	22.0	21.0	22.0	2.1	22	21
MAX	35.0	34.0	36.0	34.0	36	34
Mean	26.85	26.80	27.90	26.36	27.35	26.5
Mode	22	27	29	29	29	29
Median	27.00	27.00	27.50	27.00	27	27
SD	3.88	3.52	3.86	6.42	3.8	5.1

The maximum Angle A' measured was; AP 0^0; 21^0 and 15^0 IR ; 22^0
Minimum Angle A' measured was; AP 0^0; 8^0 and 15^0 IR; 10^0
The average was; AP 0^0; 16.2^0 and 15^0 IR; 16.6^0

Length of Lateral Malleolus:(measured from the level of tibial plafond to the Lateral malleolar tip on the ankle radiograph.)

The maximum Length of Lateral Malleolus measured was ; AP 0^0 ; 36^0 and 15^0 IR ; 34^0
Minimum length measured was ; AP 0^0 ; 22^0 and 15^0 IR ; 21^0
The average was ; AP 0^0 ;27.35^0 and 15^0 IR ; 26.5^0

DISCUSSION

Ankle fractures are very common injuries. Being a weight bearing joint there is very little scope for variation from normal to get uniformly good joint function. Reductions of these fractures have to be precise keeping the following in mind: (a) The normal relationships of the ankle mortise must be restored. (b) The weight bearing alignment must be a right ankle to the longitudinal axis of the leg. (c) The contours of the articular surface must be as smooth as possible. Unless the exact anatomy and normal parameters of the lateral malleolus are known it is difficult to assess what is normal. Yablon *et al* ,1977 in a landmark laboratory study and study of fifty patients had concluded that lateral malleolus is the key to the anatomical reduction of displaced bi-malleolar fractures. Restoring the integrity of the lateral malleolus establishes stability of the ankle. However, this did not mean that the importance of medial malleolus was lessened.

There are two anatomical features of the lateral malleolus which need to be restored during conservative/operative management of lateral malleolar fractures/bi-malleolar fractures. 1. The lateral bend and contour of the lateral surface of the lateral malleolus. 2. Length of the lateral malleolus. De Souza *et al* ,1985 presented their results of operative treatment of displaced external rotation – abduction fractures of the ankle in one hundred and fifty patients followed up for three and a half year: Their most significant contribution was the appreciation of the lateral bend of the lateral malleolus. The bend was found to be situated at an average of thirty nine millimeters from the tip of lateral malleolus. They found this bend to be ranging between 9 to 22 degrees average being 13 degrees. They opined that plates used in this region should be appropriately bent. Straight plates would cause narrowing of lateral clear space (talo-fibular joint) causing subsequent degenerative changes. (Fig No. 9 & 10). We have found this bend (Angle A fig.6, 7, 8) to range from 8 degree to 21 degree (average 16.2 degree) in antero posterior radiographs and 10 degree to 22 degree (average 16.6 degree) in 15 degree internal rotation view.

We have also taken into account the downward second bend (Angle B and bend (Angle C) Fig.6, 7, 8) of the lateral surface. The value of these two bends in pre-contoured plate is self-evident. However, due to small tubercles or ridges on the rough lower half of lateral surface of the lateral malleolus angle C could vary considerably: Range of angle was 19 degree to 45 degree in antero posterior radiographs and 22 degree to 50 degree in 15 degree internal rotation radiographs. There was lesser variation in the angle B: Between 12 degree to 25 degrees in antero posterior radiographs and between 10 degrees and 26 degrees in 15 degree internal rotation radiographs. We therefore recommend per operative contouring of plates using templates for better accuracy.

Figure 9 Showing good contouring of plate

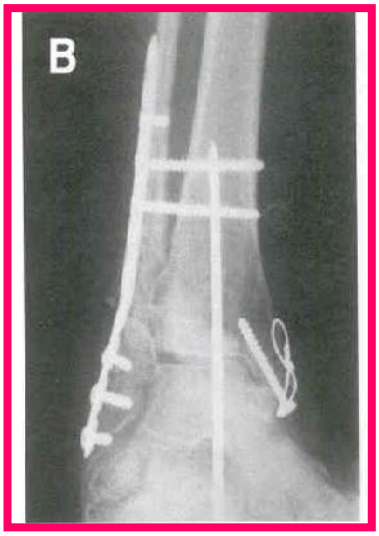

Figure 10 Showing lack of contouring with crowing of lateral clear space

The Vassal principle (Mc Daniel and Wilson, 1977) states that the fibular fracture is referred to as the dominant fracture in repair of ankle fractures and restoration of its anatomical length takes precedence over repair of inferior tibia-fibular syndesmosis. Reduction of the major fibular fracture in bi-malleolar fractures would allow other fracture fragments to fall into proper alignment. Klossner 1962 and Mc Dade 1975 had given criteria for reduction of lateral malleolar fractures in which fibular shortening was not acceptable. Vander Griend 1996 voiced similar concerns for maintenance of the fibular length. The restoration of fibular length can be indirectly ascertained by the Talo-crural angle as mentioned by Isman & Inman 1969 and refined by Sarkisian and Cody 1976. However, Phillips *et al* 1985, De Souza *et al* 1985 and Vander Griend *et al* 1996 were not convinced that differences in Talocrural angle were a reflection of change in fibular length.

We have thus endeavored to measure the length of the lateral malleolus from the level of the tibial plafond in antero posterior

radiographs for comparison with the opposite normal ankle. We have also measured the length of the lateral malleolus in cadaveric fibulae Measurements of the width of the lateral malleolus in coronal and sagittal planes have also been taken to help in use of plates of proper width for use along lateral surface of fibula or as an anti glide plate on its posterior surface.

CONCLUSION

This study has provided new data on the contour of the lateral surface of the lateral malleolus as well as the length and width of the lateral malleolus. It is hoped that this information will be helpful in designing of pre-contoured plates for the lateral malleolar fractures. We recommend the routine radiographs for measurement of length of opposite normal ankle for restoration of length of lateral malleolus especially in comminuted and long oblique fractures.

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