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Morphometry of the talocrural joint

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Summary: Based on two orthogonal radiologic views, the authors present a morphometric study of the talocrural joint. In 50 normal subjects, 10 parameters were measured and divided into 3 groups: the distal tibial joint surface parameters, the malleolar parameters and the talar parameters. These parameters were treated in both a descriptive and a correlative analysis. If the talocrural joint is a hinge joint whose talar articular surface can be simplified and classed as a cylinder segment, it is possible to calculate its curve radius. Then the correlative analysis allows to define the talar parameters and the corresponding parameters of the distal tibial joint surface. The malleolar parameters are independent factors. This study is the first morphologic analysis to serve as a basis for an ankle arthroplasty.

Morphométrie de l'articulation talo-crurale

Résumé : A partir de deux incidences radiologiques orthogonales, les auteurs proposent une étude morphométrique de l'art. talo-crurale. Sur une population de 50 sujets non pathologiques, dix paramètres ont été mesurés et répartis en trois groupes : le groupe des paramètres de la surface articulaire distale du tibia, le groupe des paramètres malléolaires, le groupe des paramètre du talus. Ces paramètres ont fait l'objet d'une analyse descriptive et d'une analyse corrélative. Si l'art. talo-crurale est une ginglyme dont la surface articulaire du talus peut être simplifiée et assimilée à un segment de cylindre, les auteurs, par le calcul, peuvent en définir le rayon de courbure. L'analyse corrélative permet alors de définir les paramètres du talus et les paramètres correspondant de la surface articulaire distale du tibia. Les paramètres malléolaires en restent indépendants. Ce travail est une première analyse morphologique pour concevoir une arthroplastie de cheville.

Key words: Talocrural joint — Ankle arthroplasty

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"We can see the patient walk without any hesitation, run, jump, being able to pursue his occupations and practice sports with an insignificant disability"
So said Watson Jones [12] in praise of the talocrural arthrodesis. It is true that this surgical operation improves in a significant way the pain of many destroyed joints, provided that the surgical technique allows primary fusion and provided that the fixation is achieved in a good position of the hind-foot (valgus, lateral rotation, retropulsion) and that the distal joints are free [3, 6, 11]. However, arthrodesis is still an unnatural procedure, indicative of surgical failure, particularly in the case of the talocrural joint, "queen of the hind-foot joints" according to Farabeuf. Undeniably, this is the reason why some surgical teams [4, 7, 10] try to create a prosthesis allowing restoration of the joint kinematics, i.e. a mobile, painless and stable joint.

Any talocrural implant must restore a normal walking pattern, by allowing minimal joint motion of 10° dorsiflexion and 20° plantarflexion. To walk downstairs in comfort needs an additional 10° dorsiflexion [1, 2, 9]. Papas [4] showed the effect of the curve radius of such an implant on mobility and stability. If the curve radius is less than normal, bending amplitude increases and the ligaments are relaxed, causing joint instability. If, on the contrary, the curve radius is greater than normal, there is no instability, the ligaments are tightened too soon and joint motion is limited [in 4]. This implies the necessity for an implant which would best reproduce the curve radius of the talar tenon; a resurfacing implant must restore the anatomy. Hence the current importance of a knowledge of the morphometry of the talocrural joint. This prospective study aims to define the joint morphometry from the radiographic data.

Material and methods

Fifty subjects whose average age was 37 (range 20 to 70) were selected excluding any patient with antecedent affections of the joint studied. There were 32 men and 18 women. For each, we first made an AP X-ray of the ankle. An ideal AP view individualises the talar tenon within the tibiofibular mortice; since the bimalleolar axis is not strictly frontal but backwards and laterally oblique, a strict A-P view of the ankle must be done in medial rotation of the foot, so that the bimalleolar axis stands out in the frontal ground of the film. In practice, this requires orientation of the beam in the axis of the third toe, positioning the foot in medial rotation. The optimal positioning was actually obtained under fluoroscopy. However, in spite of these precautions, some X-rays proved imperfect and we excluded any X-ray that was not a strict AP view, ie which did not show a talar tenon perfectly centered in the tibiofibular mortice; such radiographs were repeated. We also made for each ankle a strict lateral view with an incident beam at 90° to the first, without moving the ankle. This X-ray was satisfactory if both malleoli were superimposed. This provided two orthogonal views of the joint.

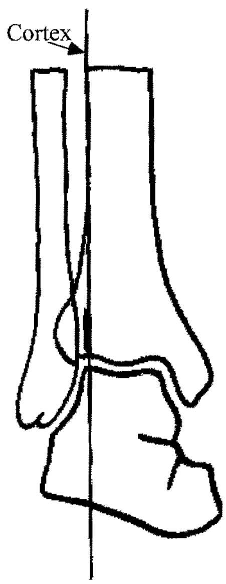


Fig. 1
The lateral cortical axis

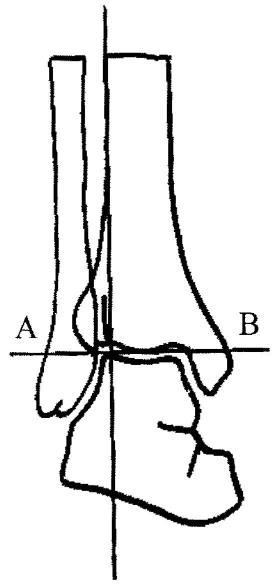


Fig. 2
The width AB of the tibiofibular mortice

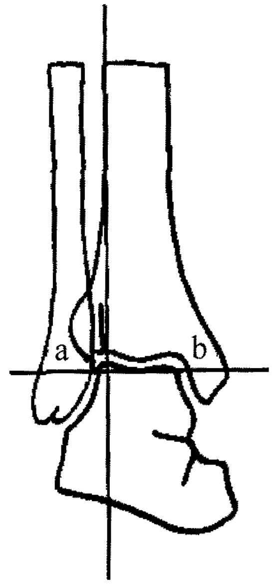
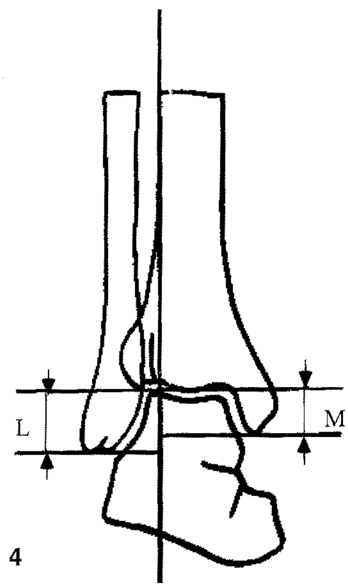


Fig. 3
The width ab of the tibiofibular mortice



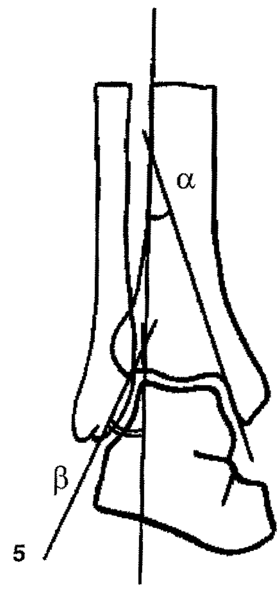


Fig. 4
The height L of the lateral malleolus. The height M of the medial malleolus

Fig. 5
The inclination α of the medial malleolus. The inclination β of the lateral malleolus

Analysis of the AP view

Ten centimeters above the articular line, the lateral cortex may be regarded as a straight line and we drew on this point the lateral cortical axis tangential to the lateral cortex of the tibia (Fig. 1). We then identified the lowest point on the distal articular surface of the tibia and drew a straight line perpendicular to the cortical axis going through this point, crossing the tibiofibular mortice at two points A and B. We measured the AB distance as representing the width of the tibiofibular mortice (Fig. 2). In the same way, on the talar tenon, we identified the lowest point of the articular surface and drew a line perpendicular to the cortical axis through this point, crossing the talar tenon at two points α and β; the ab distance was called the talar tenon width (Fig. 3). On this same AP view, we measured the height of both malleoli. M was the height of the medial malleolus and L the height of the lateral malleolus (Fig. 4). Finally, on this AP view, we measured the malleolar inclination relative to the lateral cortical axis. The inclination angle of the medial malleolus with respect to the cortical axis was termed a and that of the lateral malleolus with respect to this axis β (Fig. 5).

Analysis of the lateral view

We identified on the tibia the limits of the distal articular surface. Infront, this surface ended at a point called D; behind, it ended at a point called C. The CD distance was called the depth of the articular distal surface of the tibia (Fig. 6). On this same lateral view, at the talar level, we identified the posterior limit of the articular surface (point c) and its anterior limit (point d); the cd distance was called the depth of the talar surface (Fig. 7). The height of the talar joint surface was termed h (Fig. 7). Finally, on the lateral view, we defined the posterior cortical axis and we drew a perpendicular to this axis through point C; the angle made by

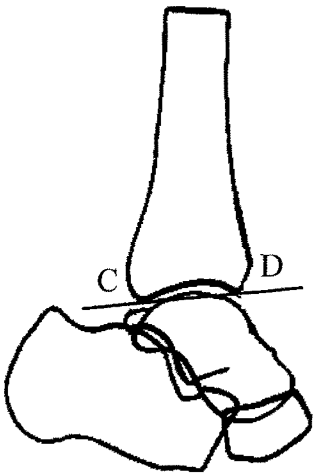


Fig. 6
The depth CD of the distal articular surface of the tibia

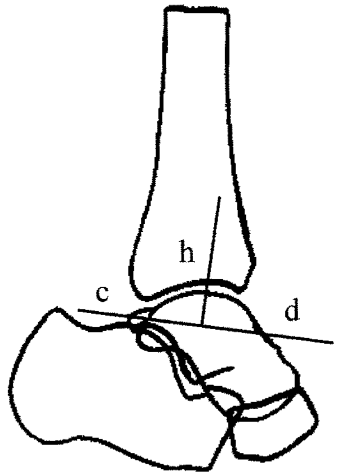


Fig. 7
The height h of the talar tenon. The depth cd of the talar surface

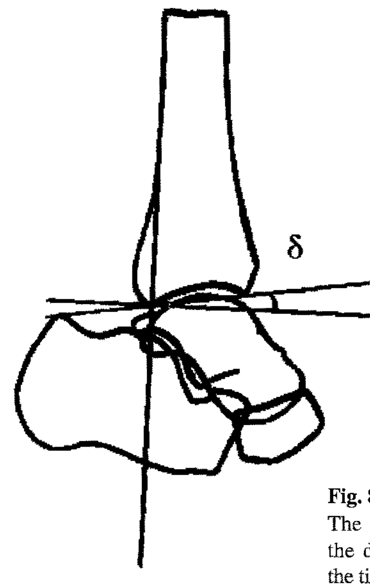


Fig. 8
The angle of inclination δ of the distal articular surface of the tibia

Table 1. Morphologic parameters of ankle joint (n=50)

	Tibia			Malleoli				Talus		
	AB	CD	δ	Medial	α	Lateral	β	ab	cd	h
Min.	29 mm	24 mm	6°	9 mm	20°	24 mm	7°	27 mm	32 mm	8 mm
Max.	40 mm	37 mm	10°	16 mm	40°	35 mm	16°	38 mm	42 mm	16 mm
Mean	34.5 mm	30.8 mm	8.3°	13.1 mm	28.1°	29.1 mm	12.6°	32.4 mm	38.5 mm	12.1 mm
SD	2.3 mm	3 mm	1.4°	1.8 mm	3.6°	2.5 mm	3.1°	2.5 mm	2.2 mm	1.5 mm

the CD line with this perpendicular was called δ, or the upfront tilt angle of the distal articular surface of the tibia (Fig. 8). The data were measured manually with the help of a ruler; angles were measured with a goniometer.

There were three groups of parameters:

- the tibial parameters (distal articular surface of the tibia):
  AB - width of the distal articular surface of the tibia,
  CD - depth of the distal articular surface of the tibia,
  δ - upfront tilt angle of the distal articular surface of the tibia.

- the malleolar parameters:
  M - the height of the medial malleolus,
  α - inclination angle of the medial malleolus,
  L - the height of the lateral malleolus,
  β - inclination angle of the lateral malleolus.

- the talar parameters:
  ab - width of the talar tenon,
  cd - depth of the talar tenon,
  h - height of the talar surface.

All these parameters were collected and data-processed for a descriptive and correlative analysis.

Results

All the parameters studied showed a gaussian distribution within our population. The descriptive characteristics of these parameters are summarized in Table 1. In each parametric group, statistical correlations were displayed. Within the tibial group, there was a strongly positive correlation between the AB width and the CD depth (n=50; r=0.77;p=0.0001). Within the malleolar group, there was a strongly positive correlation between the malleolar heights M and L (n=50; r=0.44; p=0.0002). Finally, within the talar parameters, there was a correlation between the ab width and its cd depth (n=50; r=0.44; p=0.0012). There were also statistical correlations between parameters from different groups : the AB width of the tibiofibular mortice was positively correlated with the ab width of the talus (n=50;r=0.94; p=0.0001), and with the cd depth of the talus (n=50; r=0.65; p=0.0001). The CD depth of the distal articular surface of the tibia was positively correlated with the ab width of the talus (n=50; r=0.75; p=0.0001), the cd depth of the talus (n=50; r=0.5; p=0.0002), and the L height of the lateral malleolus (n=50; r=0.43; p=0.0018). The angular parameters α, β, δ were independent parameters.

Discussion

Measuring dimensions on X-rays raises the issue of radiologic enlargement. We have ignored this enlargement coefficient, since the ankle-source distance of the ray was large enough compared to the distance of the film from the ankle joint to exclude any enlargement factor.

The literature on the morphometric data of the talocrural joint is sparse. Mariani and Patella [8]. analysed nine parameters on both AP and lateral views of the ankle in 100 adults. Six of their parameters can be compared to those of our study, namely:

- width of the tibiofibular mortice: m=35.52 mm ds=3.32 mm
- height of the lateral malleolus: m=23.72 mm ds=2.54 mm
- height of the medial malleolus: m=13.43 mm
- width of the talar surface: m=32.96 mm ds=3.13 mm
- depth of the talar surface: m=36.07 mm ds=3.41 mm
- height of the talar surface: m=10.79 mm ds=1.17 mm.

All these values are comparable to those we report. However this study did not include any correlative analysis.

Our morphometric study was a simplification of the anatomy of the talocrural joint. The articular surface of the talus, in particular, cannot be summarized as a cylinder segment; it is a tridimensional structure, wider infront than behind, excavated by a longitudinal depression. All this did not appear in our results. It is unfortunate that this study was not integrated in a morphofunctional analysis of the lower limb as a whole. Our correlative analysis showed very strong statistical correlations between the parameters of the distal articular surface of the tibia and the talar parameters, ie mathematical evidence of the articular congruence. If we accept the simplification of the talar articular surface as a cylinder segment, the morphometric data allow us to calculate the cylinder curve radius R; indeed, there is only one circle going through the three points defined by c, d and h.

Within our population R presented the following characteristics: average: 17.7 mm, standard deviation: 0.9 mm. R, by definition, is dependent on the talar surface depth and height; but the CD depth is correlated with the width ab of the talar surface, the width AB of the tibiofibular mortice and its depth CD; from cd it is possible to calculate the theoretic values of the other parameters. This defines the morphometric basis for a talocrural prosthesis.

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Reviews in brief

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Dents antrales et sinus maxillaire : étude radiologique par dentascan
(Antral teeth and maxillary sinus: a radiologic study by dentascan)
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Soc Anat Paris 27.06.97

The bony growth of the face shows that the development of the maxillary sinus depends directly on the placement of the maxillary teeth in the dental arch, the sign of a close relationship between these two anatomic structures. Dental pathology and sinus pathology are often regarded as associated, but the absence of objective radiologic criteria incriminating the teeth hampers the diagnosis of inflammations of the maxillary sinus. We decided to test the performance of a new tomographic technique combined with computer software. The study dealt with: 1) the quantitative evaluation of the relation between the maxillary sinus and the antral teeth (thickness of the bony layer); 2) determination of any possible correlation between diseases of this sinus and of the corresponding teeth. 33 healthy adult subjects were marked by the absence of clinical, dental or sinusal abnormalities. In each subject a panoramic dentascan and a complete history were obtained. A mean bony score and two scores, maximal and minimal, were established for each tooth. All the sinus and dental disorders detected by radiography were noted. The study showed that over two-thirds of the antral teeth were procident in the sinus cavity. The remaining third were separated from the sinus cavity by a maxillary bony layer which very rarely exceeded a thickness of 2 mm. Sex was not a factor involved in the degree of thickness of this bony layer. No significant relationship was demonstrated between sinus opacity and infected dental foci. However, it seemed that there was some degree of relationship between sinus pathology and the absence of a maxillary bony layer.

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