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# THE MECHANICAL AND STRUCTURAL CHARACTERISTICS OF THE TIBIO-FIBULAR INTEROSSEOUS MEMBRANE

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The tibio-fibular interosseous membrane was studied in the scanning electron microscope. It is made up of two fibrous networks, a major one composed of large diameter fibres aggregated into bundles and a fine filamentous network, without a preferred orientation, between these main fibre bundles. Mechanical studies have shown that the interosseous membrane is stronger, but less extensible, parallel to the direction of the main fibre bundles which, therefore, probably have a load bearing function.

*Key words:* structure; mechanical properties; function; interosseous membrane

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The main function of the tibio-fibular interosseous membrane is to hold the tibia and fibula together and when these bones are fractured it contributes to the stability of the fracture (Sarmiento et al. 1974). Therefore, it obviously has a mechanical function. In this study we have quantitated the tensile properties of the tissue and correlated them with the architecture as seen in the scanning electron microscope.

## MATERIALS

The interosseous membranes used in this study were obtained postmortem from the left leg of three males. They were cleaned of adhering tissue and attached muscle and cut from the edge of the tibia and fibula to produce a sheet approximately 15 cm long and 1 cm wide. Segments of the tissue which were to be examined in the scanning electron microscope were cut into squares approximately 0.5 × 0.5 cm and fixed in formal saline pH 7. The tissue specimens for mechanical testing were cut in two directions, (a) parallel to the main fibre bundles and (b) at right angles to them.

## METHODS

### *Mechanical studies*

Strips approximately 2 mm wide and 20 mm long were cut, weighed and mounted in a specially designed testing fixture (Minns et al. 1973) using Eastmans 910 adhesive. They were clamped and immersed in isotonic saline and the tests were conducted at room temperature on a table model tensile testing Instron type TM1112. The strips were extended at a constant extension rate of 0.2/minute to complete rupture.

The ultimate tensile stress was calculated from the maximum load recorded divided by the initial cross-sectional area of the specimen whereas the strain at rupture was determined from the recorded extension at maximum load divided by the initial rest length expressed as a percentage. Strips that slipped at the grips (indicated by non-linear movement of the chart pen recorder associated with the extensometer) were eliminated from the results and only strips

*Figure 1. Scanning electron micrograph of the main fibre bundles observed in the interosseous membrane (× 1,700).*

that ruptured between the grips were used in this study.

### *Scanning electron microscopy*

The specimens for scanning electron microscopy were cut in various planes and prepared by the method of Finlay et al. (1971). The samples were examined in a Cambridge Stereoscan S4 electron microscope operating at 30 KV and were photographed with an Exacta VX 3500 camera on Ilford FP4-120 film.

## RESULTS AND DISCUSSION

### *Mechanical properties of the interosseous membrane*

Table 1 is a summary of the results of the stress-strain characteristics of the interosseous membrane determined in 20 specimens parallel and perpendicular to the main fibre bundle axis. In the direction of the main fibre bundles the tissue

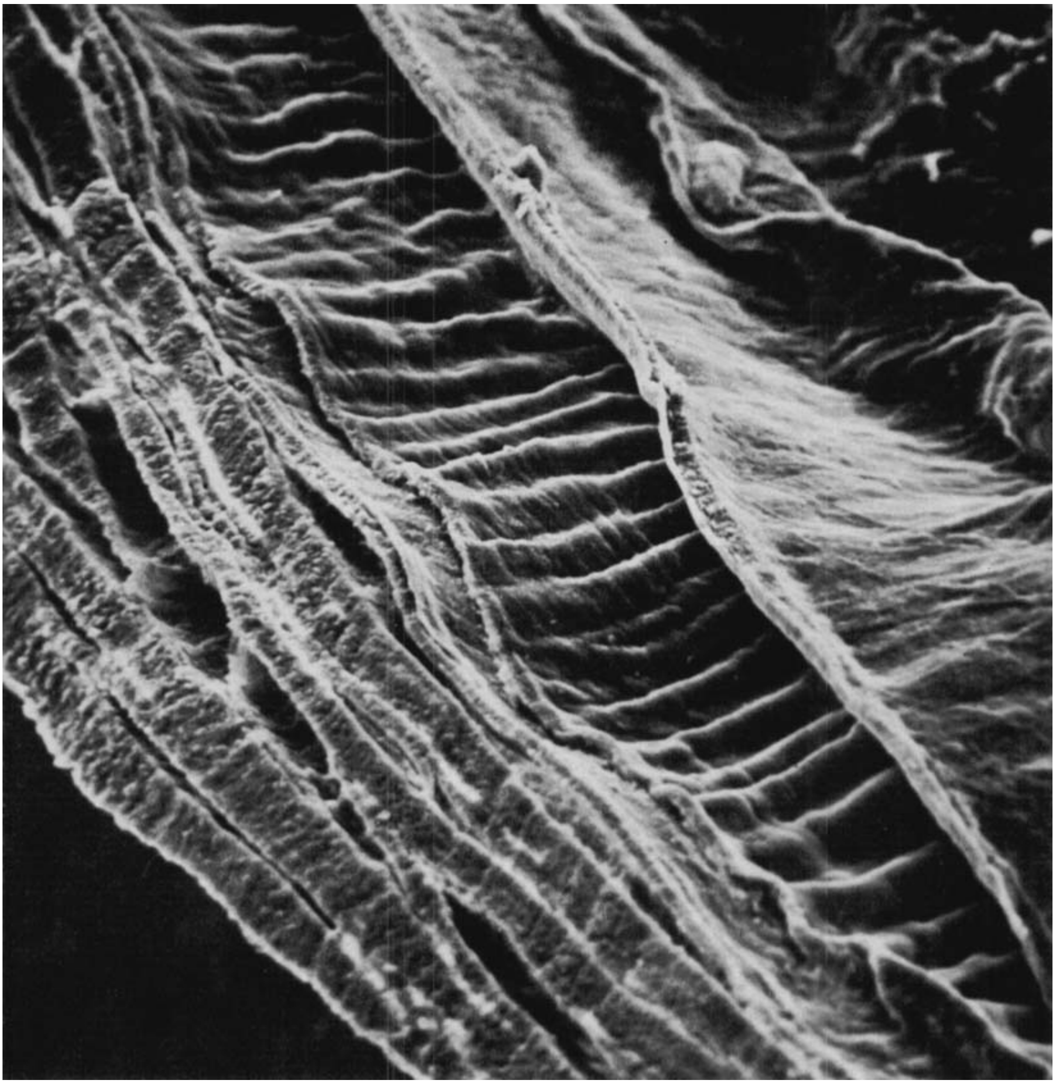

*Figure 2. Scanning electron micrograph of a cross section of the membrane showing the corrugation of fibre sheets which form the bundles at different layers (× 520).*

is 45 times stronger than perpendicular to these fibres but is much less (1/5) extensible. This result is in keeping with previous studies on load bearing collagenous tissues. For example Bullough et al. (1970) showed that the ultimate tensile strength of meniscal tissue is dependent upon the axis of loading; the tensile strength of the menisci in the direction of the principal fibre bundles was 4 to 10 times that of the strength perpendicular to the fibres.

### *Scanning electron microscopy*

Naked eye examination is sufficient to show that the major fibre bundles of the interosseous membrane join the tibia and fibula at an angle of between 20 and 30° to the vertical, running distally from the

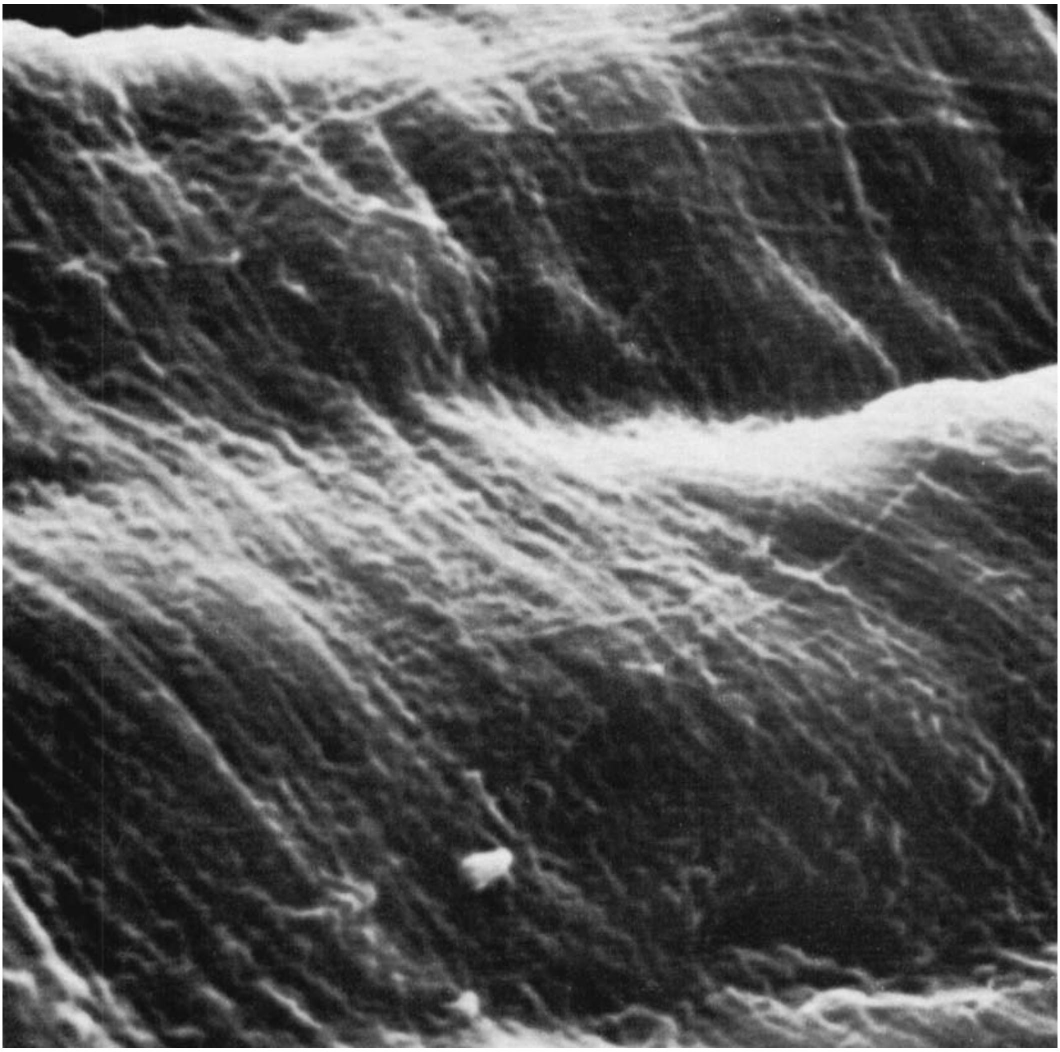

*Figure 3. Scanning electron micrograph of the surface of a corrugated fibre sheet showing fibrils passing at right angles to the main fibre bundle direction (× 16,200).*

proximal end of the tibia to the fibula. In the scanning electron microscope these main fibre bundles can be seen to consist of large fibres with a diameter ranging between 30 and 40 microns aligned parallel to the long axis of the bundle (Figure 1). Each bundle appears to contain approximately 50 of these fibres; some of them bifurcate and others are continuous. In some areas the fibres have a rather laminated structure and although the direction of the fibrils within these fibres is fairly uniform the overall direction changes from layer to layer (Figure 2). There is also a second fibrous network consisting of fine fibres with a diameter range of 0.5 to 1 micron (Figure 3) arranged as a continuous mesh.

All of these structural factors contribute to, and explain, the observed mechanical behaviour of the tibio-fibular interosseous membrane. It has been

*Table 1. The results of the mechanical tests that were conducted on interosseous membrane. The results show the mean and standard error of the Ultimate Tensile Stress and strain at rupture of 20 specimens tested in the two directions indicated.*

| | Ultimate Tensile Stress ($Kg_f/cm^2$) | Strain at rupture (%) |
|---|---|---|
| Parallel to main fibre bundle | 920 ± 205 | 7.7 ± 2.1 |
| Perpendicular to main fibre bundle | 41 ± 13 | 40.5 ± 7.1 |

shown (Minns 1975) that, on the surface of the tibial shaft, the load during walking is not carried uniformly throughout the bone but that there is an area of high tensile stress corresponding to the tibial insertion of the interosseous membrane. Kimura (1974) loaded the tibia and fibula to correspond to the walking posture and with the interosseous membrane cut, the tensile strain on the posterior side of the mid-shaft increased. Our results show the way in which the structure of the interosseous membrane correlates with its load bearing function. It should be remembered, however, that this membrane also plays an important role in stabilizing both transverse and spiral fractures of the tibia and the structure described helps resist any displacement at the fracture site (Sarmiento et al. 1974).

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