## Short Report

# Loss of the fibrocartilaginous lining of the intertubercular sulcus associated with rupture of the tendon of the long head of biceps brachii

M. BENJAMIN, J. R. RALPHS, R. L. M. NEWELL AND E. J. EVANS

*Department of Anatomy, University of Wales College of Cardiff, Cardiff, UK*

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ABSTRACT

Fibrocartilage lines the intertubercular sulcus of the humerus and protects both the bone and the tendon of the long head of biceps brachii where the tendon passes through the sulcus. It provides a smooth, resilient, lubricated gliding surface on the bone. The fibrocartilage is highly metachromatic and organised into distinct superficial and deep zones. In the superficial zone, the cells are small and the fibres run parallel to the articular surface. In the deep zone, the cells are large and rounded and the coarse bundles of fibres are interwoven. In 6 of the 26 dissecting room cadavers examined the tendons were completely ruptured. In these, the fibrocartilage was replaced by loose connective tissue that resembled the synovium of the tendon sheath. The results suggest that bone fibrocartilage exhibits dynamic behaviour in response to changes in its environment, in the same manner as tendon fibrocartilage.

### INTRODUCTION

Tendons contain fibrocartilage where they pass around bony pulleys, providing a smooth gliding surface and enabling them to resist compression (Vogel & Koob, 1989; Ralphs et al. 1991). A corresponding fibrocartilaginous coating is also present on the opposing surface of the bone (Stilwell & Gray, 1954). The composition, development and ageing of tendon fibrocartilage has recently received considerable attention. It is a dynamic tissue that varies in composition according to site, age and loading (Benjamin et al. 1986, 1991; Vogel & Koob, 1989; Evans et al. 1990; Ralphs et al. 1991, 1992). However, little is known of the structure or behaviour of fibrocartilage on bony surfaces. Here, we describe the fibrocartilaginous lining of the intertubercular sulcus (bicipital groove) of the humerus in elderly dissecting room cadavers. In the course of the study, we found 6 cadavers where the tendon of the long head of biceps brachii had ruptured and disappeared from the sulcus. This provided us with a natural experiment to investigate the effects of the presence and absence of a tendon on fibrocartilage covering a bony surface.

### MATERIALS AND METHODS

Shoulders from 26 dissecting room cadavers were examined by gross dissection. Tendons of the long head of biceps brachii were found to be ruptured in 6 cadavers (3 male, 3 female). Specimens were taken for histology from these 6 bodies and from 9 randomly selected normal bodies (4 male, 5 females). The ages of the 2 groups were similar (normals 76–94 y; ruptured 76–92 y).

A 2 cm length of the tendon and the associated intertubercular sulcus were taken from each body from beneath the transverse ligament. Specimens were placed in 10 % neutral buffered formol saline for 1 wk, decalcified in 2 % nitric acid, dehydrated in graded concentrations of alcohol, cleared in xylene and embedded in paraffin wax. Fifteen longitudinal sections (8 μm) were taken from the middle third of each block. This ensured that the central portion of the groove, in full contact with the tendon, was examined.

Correspondence to Dr M. Benjamin, Department of Anatomy, University of Wales College of Cardiff, Cardiff CF1 3YF, UK.

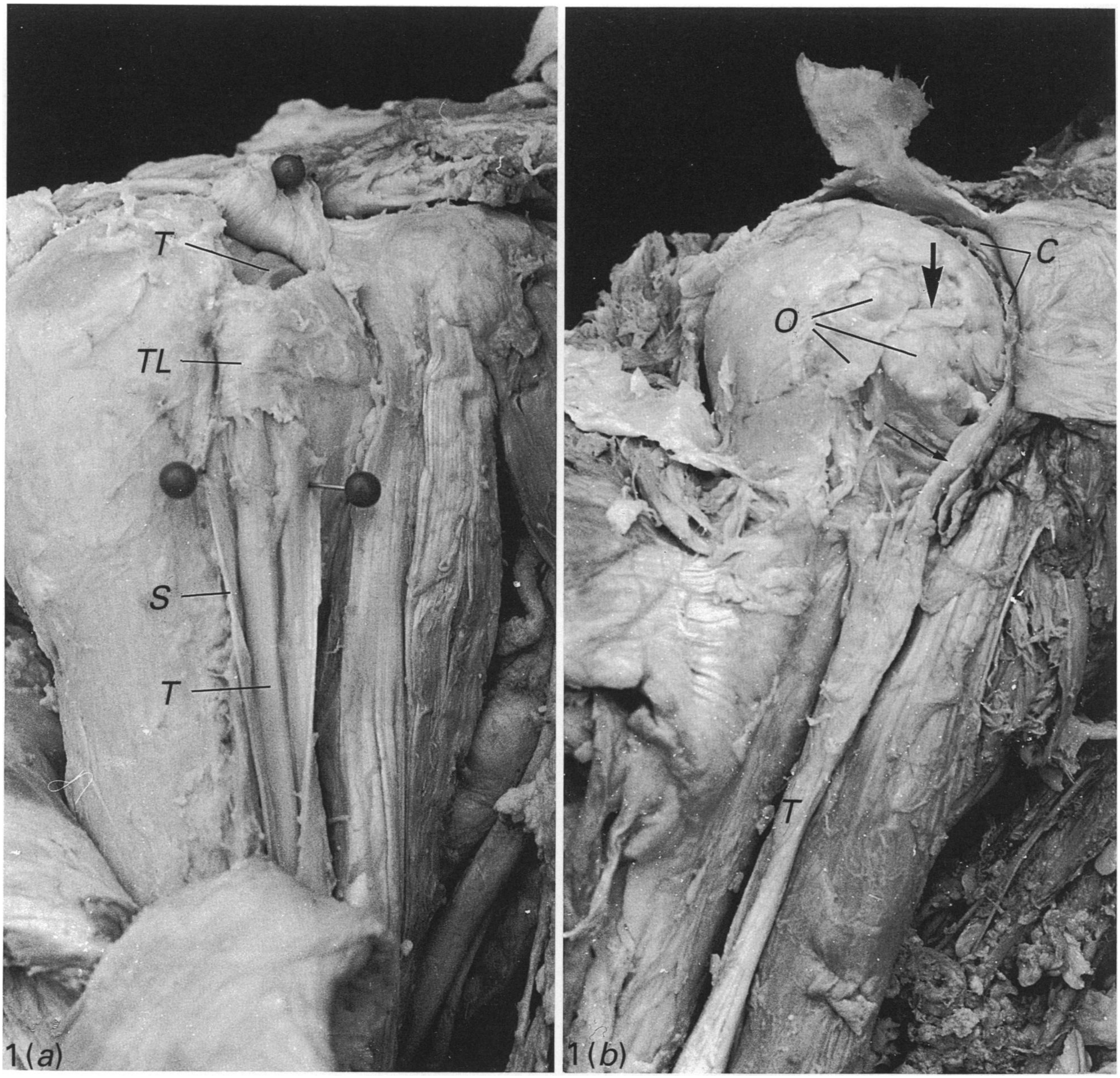


Fig. 1. Gross anatomy of normal and ruptured tendons (*T*) of biceps brachii. (*a*) Normal tendon. The tendon lies in a sheath (*S*) and is held in the intertubercular sulcus by the transverse ligament (*TL*). The tendon is clearly visible both above and below the transverse ligament. (*b*) Ruptured tendon. Although the distal portion of the tendon is intact, the proximal portion that is related to the head of the humerus is missing and no transverse ligament can be seen. Osteophytes (*O*) obscure the intertubercular sulcus but a remnant of the tendon sheath emerges from it (thick arrow). A further part of the sheath (thin arrow) adheres to the capsule (*C*).

Sections were stained with Masson's trichrome or with toluidine blue for metachromasia of glycosaminoglycans.

## RESULTS

### *Gross anatomy*

The gross appearance of normal and ruptured tendons is compared in Figure 1. Normal tendons lay in a thick fibrous sheath which adhered to the humerus in the intertubercular sulcus. In bodies where the tendon was completely ruptured, the sheath remained in the sulcus. Proximal to the rupture, the tendon had either disappeared or remnants were flattened and displaced posteriorly behind the head of the humerus. Distal to the rupture (below the sulcus), the remaining tendon had fused with adjacent structures, for example the capsule of the shoulder joint (Fig. 1*b*). In all bodies with a ruptured tendon, there were osteophytes around the lips of the sulcus.

### *Histology*

In bodies where a normal tendon was present, the

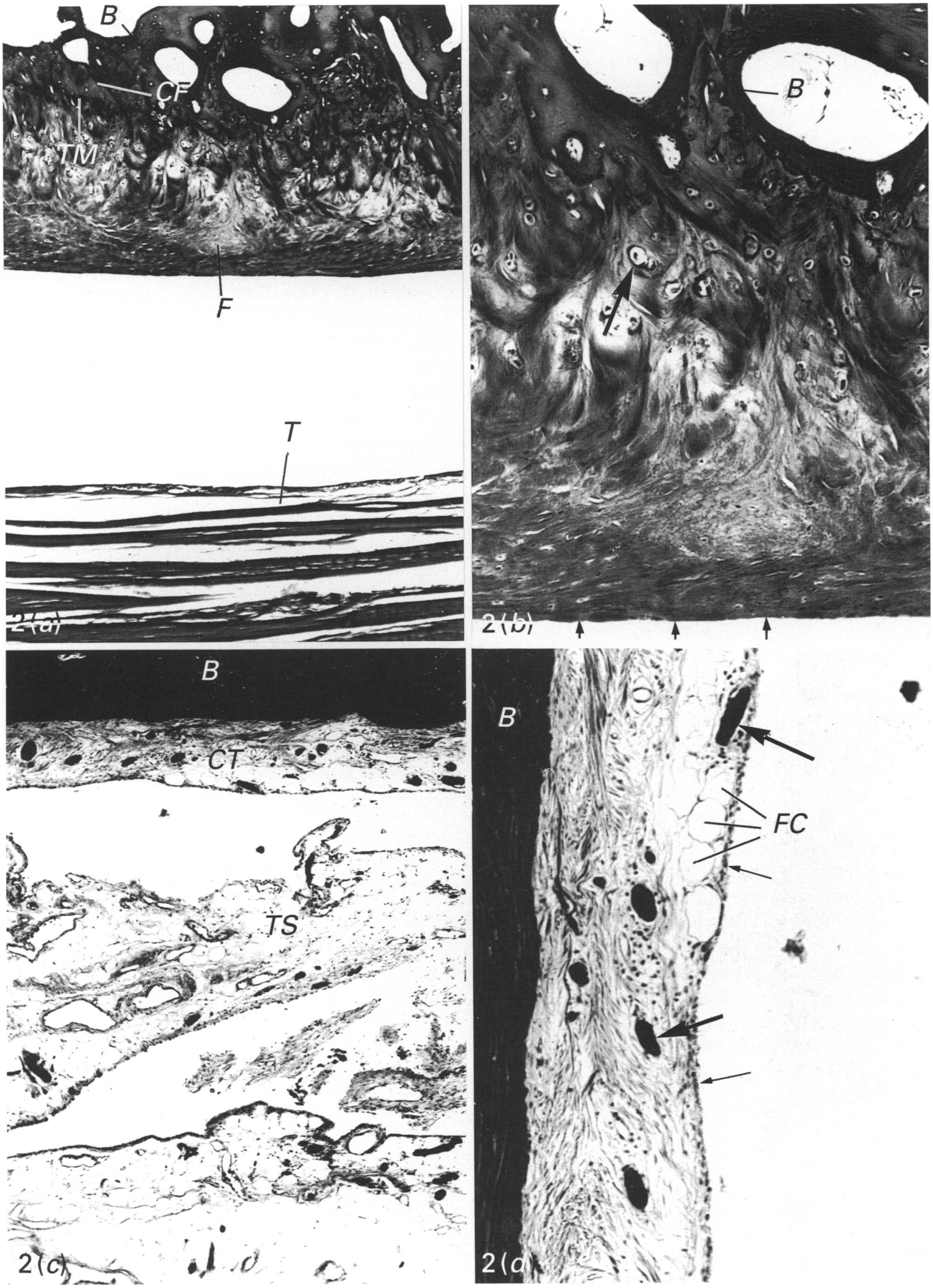


Fig. 2(*a–d*). For legend see p. 284.

bone of the intertubercular sulcus was covered with a thick layer of fibrocartilage which had a smooth superficial surface. The deepest portion was calcified, providing a transition between nonmineralised fibrocartilage and bone (Fig. 2*a, b*). There was no periosteum. The fibrocartilage was highly metachromatic and had a distinct organisation into superficial and deep zones. Towards the surface, the cells were small and the fibres in the extracellular matrix were arranged more or less parallel to the articular surface. In the deeper parts of the tissue the cells were large and rounded and coarse bundles of fibres were interwoven (Fig. 2*b*).

The tendon itself contained no fibrocartilage where it passed through the intertubercular sulcus. It was surrounded by a sheath that was continuous with the fibrocartilage. In cadavers where it was ruptured, the sheath remained in the sulcus, but was empty or contained only small quantities of tendon fragments. There were no unbroken tendon fibres running through the sulcus and there was no fibrocartilage on the bone. It was replaced by a nonmetachromatic, vascular loose connective tissue which was continuous with the synovium of the tendon sheath (Fig. 2*c, d*).

## DISCUSSION

The fibrocartilage lining the sulcus protects both the tendon and the bone where they rub against each other. The absence of fibrocartilage from the tendon was unexpected. Tendons contain fibrocartilage where they bend around bony pulleys and are compressed against the bone (Vogel & Koob, 1989). The absence of fibrocartilage suggests that no significant compressive forces act upon the tendon. This is probably because the tendon does not change direction within the sulcus—it bends around the head of the humerus proximally, above the transverse ligament. We suggest therefore that the primary function of the fibrocartilage lining the sulcus is to facilitate gliding movements of the tendon by providing a smooth, resilient and lubricated surface. Tendon fibrocartilage disappears when stresses on the tendons are altered experimentally (Gillard et al. 1979). We show that bone fibrocartilage also exhibits dynamic behaviour in response to changes in its environment, in this case the loss of the tendon sliding over the bone.

The structure of normal and pathological sulci may give clues about how bone fibrocartilage develops. In normal sulci, the fibrocartilage, tendon sheath and the periosteum on the adjacent portions of the humerus are continuous. In the absence of a tendon, fibrocartilage is replaced by loose connective tissue which resembles the synovial lining of the sheath. In tendons, fibrocartilage can develop from, or in association with, synovium or epitenon (Evanko & Vogel, 1990; Ralphs et al. 1992). Bone fibrocartilage can develop from perichondrium (A. Rufai, M. Benjamin and J. R. Ralphs, unpublished observations). It seems possible therefore that the sulcal fibrocartilage develops from the tendon sheath and/or periosteum.

We cannot comment on the time course of disappearance of the fibrocartilage as we do not know how long the tendons had been ruptured. However, changes such as the disappearance of proximal fragments of the tendon and the fusion of distal fragments to neighbouring structures indicate that they were old injuries. Osteophytes encroaching into the intertubercular sulcus could have caused wear of the tendon and are associated clinically with joint stiffness and pain (Kessel, 1976). This might affect tendon use prior to rupture, reduce tendon movement within the sulcus and lead to the onset of fibrocartilage loss.

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Fig. 2. Histology of the intertubercular sulcus in bodies with normal and ruptured tendons of biceps brachii. (*a*) Where the tendon (*T*) is intact, fibrocartilage (*F*) covers the surface of the bone (*B*). The deepest portion of the fibrocartilage is calcified (*CF*) and lies beneath a tidemark (*TM*). Masson's trichrome, ×40. (*b*) The fibrocartilaginous lining of the sulcus carrying a normal tendon has a fibrous matrix and contains a few round cells (large arrow). The surface of the fibrocartilage is at the bottom of the figure (small arrows). *B*, Bone. Masson's trichrome. ×110. (*c*) In bodies where the tendon is ruptured, only the tendon sheath (*TS*) remains in the sulcus and the bone (*B*) is covered with vascular connective tissue (*CT*). Masson's trichrome, ×40. (*d*) In bodies with ruptured tendons, the connective tissue on the bone (*B*) resembles the synovium of the tendon sheath. Beneath a surface lining of cells (thin arrows), there are numerous blood vessels (thick arrows) and fat cells (*FC*). Masson's trichrome, ×110.

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