Arch Jpn Chir 53(6), 736~741, Nov., 1984

Histological Study on The Development of Punctiform Ligament Insertion Using Ligamentum Collaterale Cubiti

WOLFGANG KÜSSWETTER

Department of Orthopaedic Surgery, University of Würzburg, Federal Republic of Germany
(Director: Prof. Dr. A. RÜTT)

YASUSUKE HIRASAWA

Department of Orthopaedic Surgery, Kyoto Prefectural University of Medicine
(Director: Prof. Dr. K. SAKAKIDA)
Recived for Publication, July 3, 1984.

Summary

The growth development of the humeral insertion area of the ligamentum collaterale ulnare cubiti was studied in autoptic specimens of different age groups. Dependent on the age of the donors, gradual changes from cartilageneous insertion to the typical 4-zone insertion could be observed. Punctiformly inserted tendons and ligaments exhibited similar growth development in the insertion area.

Introduction

Joint stability is strongly dependent on the stability of its ligaments. Thus, the osseous insertion of joint ligaments is of clinical importance in maintaining the stability of the joint under various forms of stress acting onto the joint as traction and shearing forces.

It was DOLGO-SABUROFF[3] in 1929, who described 4 different zones in the insertion area of the patellar tendon. His findings were confirmed by COOPER and MISOL (1970)[2] histologically and by transmission electronmicroscopy of the insertion area of the patellar tendon in mongrel dogs.

SCHNEIDER (1958)[7] proved this model for punctiformly inserting tendons with small cross-sections of the insertion area and was able to demonstrate the course of development.

KÜSSWETTER (1981)[6] and KÜSSWETTER and SCHMID (1975)[5] showed the growth development of ligament insertion over an area using the example of the membrana interossea antebrachii. Investigations of the course of growth development of punctiformly inserting joint ligaments, however, have as yet not been carried out.

The observations in the area of insertion of a syndesmosis with a broad area insertion led us

Key words: Punctiform ligament, Ulnar collateral ligament, Four zone formation.
索引語：点状靱帯付着，肘関節尺側々副靱帯，四層形成.
Reprint requests: Yasusuke Hirasawa, Department of Orthopedic Surgery, Kyoto Prefectural University of Medicine, Kamigyo-ku, Kyoto 602, Japan.

to carry out corresponding examinations on the growth development of a punctiformly inserted ligament using the ligamentum collaterale ulnare cubiti as an example.

Material and Methods

For examination of the insertion area, samples were taken from the humeral insertion of the ligamentum collaterale ulnare cubiti of 23 postmortem human elbows of different donor age groups. The arm specimens were taken from the donors within a maximum postmortal interval of 48 hours. The specimens were then immediately brought into a moisture chamber with maintained environment conditions of 100% relative humidity and constant temperature of 25°C where they were dissected. The soft tissues including the overlaying flexor muscles were carefully removed and the ligamentum collaterale ulnare was clearly exposed. After severance of the ligament and the removal of the synovial joint-capsula the epicondylus ulnaris together with a ligament stump was removed from the humerus with the help of a chisel. The samples were then preserved in 4% formaldehyde and decalcified in 25% titriplex-solution. After corresponding microtechnical preparation in paraffin as well as in methylacrylate serial sections of 5-6 μ thickness were performed and stained. The histological investigations were then carried out by light-and polarisation microscopy.

Results

The histologically examined samples were divided into five groups according to the age of the donors (Table 1).

In group A, the foetal samples and those of early childhood, we were able to observe a connection between the collagenous ligaments fibres and the fibre structures in the border zone of the apophyseal cartilage. Bundles of fibres penetrate to the basic substance of the cartilage like palisades, and then disappear more and more towards the centre. In an intermediate zone, there are round, cartilagineous cells as well as spindle-like cells, and we can recognize a increasing density of fibres form the centre to the periphery (Fig. 1)

With increasing growth, the ossification in the insertion area also increases. This phenomenon can be observed in the samples of group B (Fig. 2).

As growth continues, the zone of epiphyseal cartilage becomes thinner and thinner, being replaced centrally by bone formation.

Table. 1.

Group	Age of Donor	Number of Specimens
A	8th fetal month—2 month of age	5
B	3rd month of age—6 years	5
C	7 years—17 years	3
D	18 years—60 years	5
E	over 60 years of age	5

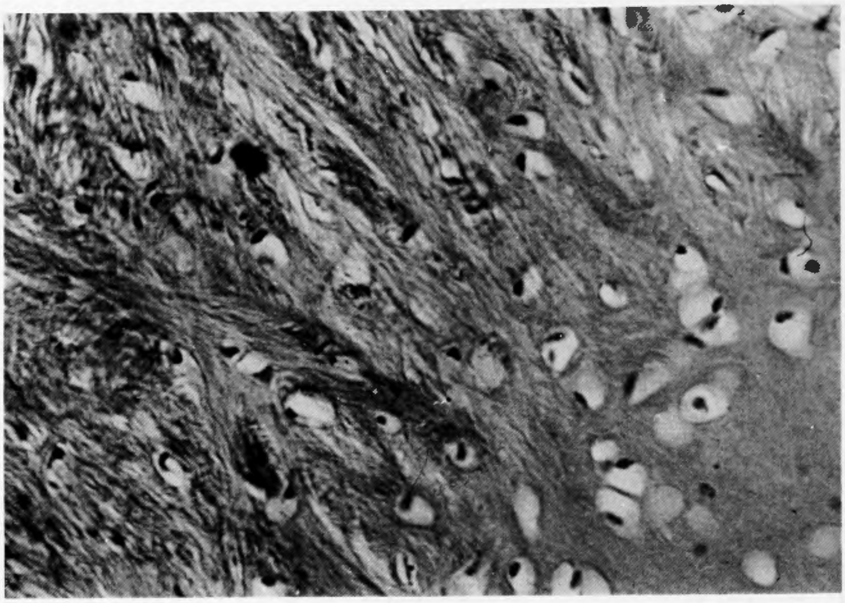

Fig. 1. Age group A, (250×)
The ligament fibres structures penetrate to the cartilage of the aphophyses.
Bundles of fibres connect with the matrix of the cartilage.

When the apophyseal layer of cartilage decreases a linking together of the collageneous fibres of the ligament and the collagenous system of bone passing through the remaining thin layer of cartilage can be observed (Group C). (Fig. 3).

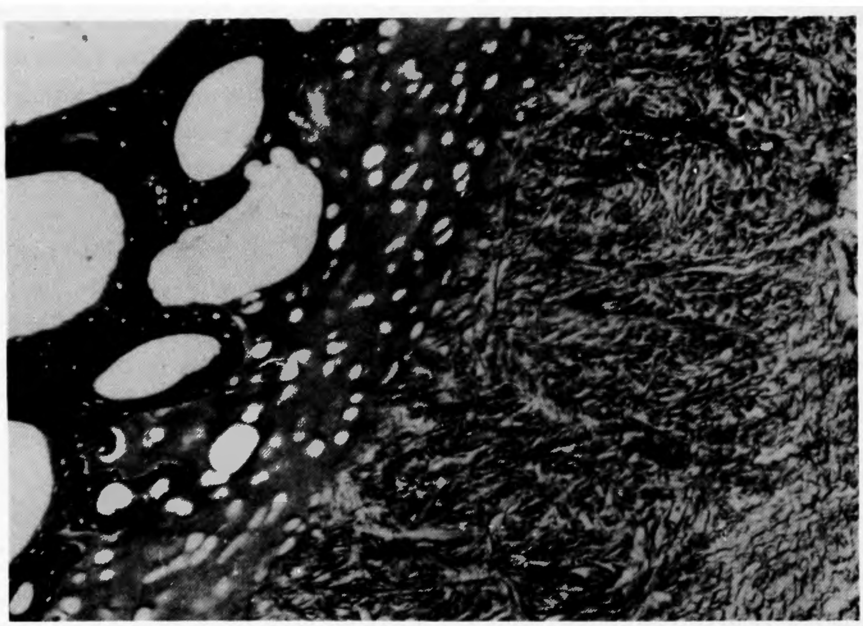

Fig. 2. Age group B, (100×)
The zone of epiphyseal cartilage gradually becomes thinner.

Fig. 3. Age group C, (300×)
The fibre structures of the ligament pass through the remaining thin layer of cartilage and link together with the collagenous system of bone.

When growth is completed—as it can be demonstrated in the samples of Group D—a calcification of the layer of cartilage next to the bone begins to form towards the centre. This shows up on the PAS staining as a deep purple strip. On the periphery, round, cartilageneous cells

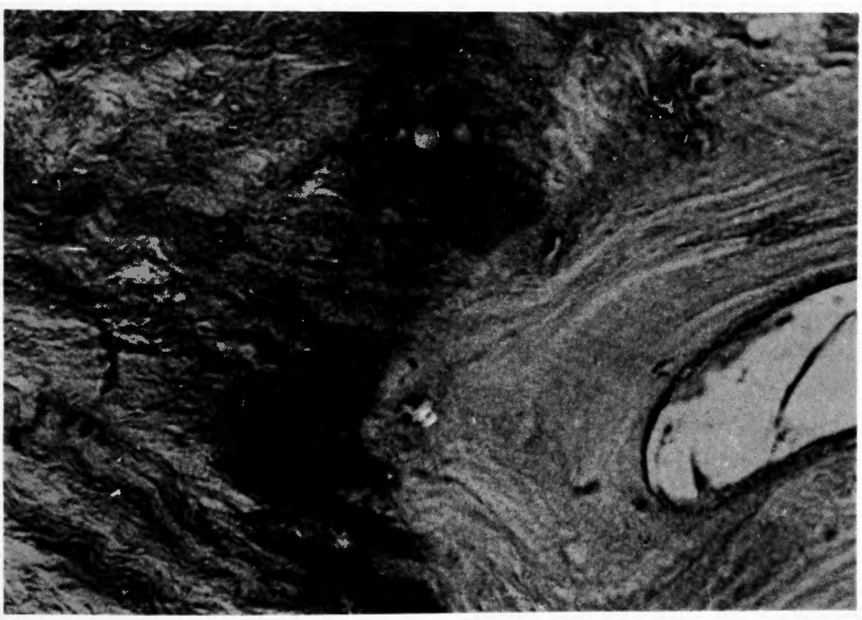

Fig. 4. Age group D, (120×)
Calcification of the layer of cartilage next to the bone begins to form (blue line). The 4-zone formation of the insertion area is herewith completed.

in uncalcified tissue remain (Fig. 4).

The formation of the insertion area is herewith completed, with a fact which was substantiated by all samples of Group E.

Discussion

SCHNEIDER (1958)[7] confirmed the observation of HAVERS (1961)[4] that tendons which are stressed by high tractional loads penetrate the periosteum and insert directly into the bone. In this examinations of growth development of osseous tendon insertion, SCHNEIDER[7] points out that, from the second to the third fetal month onward, the fibres of the tendon are slowly and progressively built into the cartilage tissue of the apophysis, as a consequence of the enlargement of the cartilageneous matrix of the bone. After the appearance of the apophyseal ossification centre, the fibres of the tendon are only gradually built into the bone as this ossification centre grows larger.

According to the interpretation of BECKER and KAHL (1978)[1], calcification of the zone of the cartilage is not a passive process but a ersult of the proliferative growth of the cartilagenous cells. Moreover the zone of cartilage is compared by VIDEMANN (1970)[9] with an epiphyseal growth plate. Even after completion of skeletal growth, a zone of cartilage remains in the area of tendon insertion.

These observations of growth development in punctiform tendon insertion areas are very similar to our results in the insertion area of a punctiformly inserting joint ligament.

Functional stress of tractional and shearing forces plays an important part as a stimulus of the transformation processes in the insertion area of ligaments and tendons.

As well the ingrowth of collagenous fibres towards the bone as the formation of the 4-zone insertion with cartilageneous layers are dependent on the active forces.

SENST (1974)[8] who investigated osseous insertion areas of tendons could prove a direct relationship between thickness of the cartilageneous layers and the amount of stress applied. That covers the observation of SCHNEIDER[7] who observed that the microstructural strength of osseous tendon insertion is dependent on sex, age and profession.

Functional stress is a main cause for the metaplastic changes in the osseous insertion of ligament inserting over a wider area, as we were able to show in the membrana interossea antebrachii (KÜSSWETTER and SCHMID[5], 1979). It also acts in the growth development of punctiform ligament insertion leading to the typical 4-zone type of logament insertion: free ligament- -uncalcifibrocartilage- -calcified fibrocartilage- -bone.

This shock absorbing system guarantees a maximum of resistance against high traction and shearing forces.

References

1) Becker W & Krahl H: Die Tendopahien. Georg Thieme Verlag, Stuttgart (West Germany), 1978, p.p. 1-112.

2) Cooper RR and Misol S: Tendon and ligament insertion. J. Bone and Joint Surg **52-A**: 1-20, 1970.

3) Dolgo-Saburoff B: Über Ursprung und Insertion der Skelettmuskeln. Anat. Anz **68**: 30-87, 1929.
4) Havers C: Osteologia Nova. Smith, London (England), 1691, p. 1.
5) Küsswetter W and Schmid K: Die Membrana interossea antebrachii das gemeinsame Gelenkband der Radioulnargelenke. Zeitschr. f. Orthop **117**: 767-783, 1979.
6) Küsswetter W: Morphologie und Biomechanik der Membrana interossea antebrachii. Georg Thieme Verlag, Stuttgart (West Germany), 1981, p. 1.
7) Schneider H: Zur Struktur der Sehnenansatzzonen: Z. Anat. Entwickl-Gesch **119**: 431-456, 1956.
8) Senst W: Beitrag zur feingeweblichen Struktur der Band-Knochenverbindung. Zbl. Chir. **99**: p. 275, 1974.
9) Videman T: An experimental study of the effects of growth on the relationship of tendons and ligaments to bone at the site of diaphyseal insertion. Acta orthop. scand. Suppl **131**: 0-22, 1970.

和文抄録

肘部側副靱帯付着部に関する組織学的研究

Würzburg 大学整形外科学教室（指導．A. RÜTT 教授）
WOLFGANG KÜSSWETTER

京都府立医科大学整形外科学教室（指導：榊田喜三郎教授）
平 沢 泰 介

人体において靱帯組織は骨・関節の支持組織として重要な役割を果している．靱帯は巾広い付着部をもつ骨間膜のようなものと，本研究で用いられた肘部尺側側副靱帯のように点状の付着部をもつものとの２つに分けられる．本研究では後者の靱帯付着部の年令による変化について追求を行った．

資料は８カ月の胎児より，60才以上の23屍体の上肢であり，年令により５群に分け，肘関節尺側々副靱帯の上腕骨付着部について光学顕微鏡と偏光顕微鏡を用いて観察した．

胎児においては靱帯の膠原線維束は軟骨組織へと連続しており，加令とともに付着部の骨化が進行していた．成人においては靱帯の膠原線維束は線維軟骨層，石灰化線維軟骨層そして層状骨へと４層を形成して連続していた．このような４層の形成には生後に加わる張力などの力学的要素が重要な役割を果たしていることが推察された．