Blood supply in the bicipital groove: A histological analysis

Martin Hufeland,[1] Glyn Hamed,[1,2] Hannes Kubo,[1] Hakan Pilge,[1] Rüdiger Krauspe,[1] Timm Filler,[2] Thilo Patzer[1,3]

[1]Clinic for Orthopedics, and [2]Institute of Anatomy I, University Hospital, Heinrich-Heine University, Düsseldorf; [3]Centre for Shoulder, Elbow, Knee and Sports Orthopedics, Schön-Klinik, Düsseldorf, Germany

Abstract

The vascular anatomy in the closed bicipital groove with the long head of the biceps brachii muscle tendon (LHBT), its mesotenon and the transverse ligament intact has not been analyzed on a histological level yet. An anatomic dissection and histologic study was conducted by using 24 cadaveric formaldehyde fixated shoulders. The bicipital groove including the LHBT and its intact sheath was cut *en-bloc*, fixated, sliced in 7 µm sections, Azan stained and the vascular anatomy analyzed under light microscopy. Each sideward branch deriving from the main ascending branches of the anterior humeral circumflex artery (ACHA) in the mesotenon of the LHBT was identified and followed through multiple sections to identify its direction and area of supply. Per specimen, a mean of 2.71±1.85 branches could be identified running through the soft tissue of the mesotenon towards the osseous walls of the groove. Of the total 65 arterial branches in all specimens, 22 (33.8%) were running into the medial wall of the groove and 40 (61.5%) into the lateral wall (P<0.01). The results indicate that branches of the ACHA in the mesotenon of the LHBT provide blood supply not only to the tendon but to the osseous bicipital groove as well and here significantly more to the lateral than to the medial osseous wall. In addition, Pacini-like mechanoreceptors could be identified in the mesotenon in 9 (37.5%) of the specimens which has not been described up to now.

Introduction

The bicipital groove which is bounded by the lesser tuberosity medially and the greater tuberosity laterally contains the tendon of the long head of the biceps brachii muscle (LHBT).[1] Taylor *et al.* defined three distinct anatomic zones of the bicipital groove: Zone 1extends from the articular margin to the distal margin of the subscapularis tendon, Zone 2 extends from the distal margin of the subscapularis tendon to the proximal margin of the pectoralis major tendon and Zone 3 is defined as the subpectoral region.[2]

The osseous bicipital groove in zone 1 is in the average about 30 mm long, 5 mm deep and covered by the so called transverse humeral ligament formed by tendinous fibers of the subscapularis and supraspinatus muscles.[1,3-5] The segment of the LHBT in the groove is circumferentially covered in synovial tissue and accompanied by its mesotenon.[2] Blood supply to the anterior humeral head, the bicipital groove and the LHBT in this segment is mainly provided by the anterior circumflex humeral artery (ACHA).[6,7] The ACHA bypasses the bicipital groove below the LHBT, sends out an anterolateral branch proximally along with the LHBT and, after delivery of smaller lateral branches, penetrates into the greater tuberosity to mainly supply the anterior and medial part of the humeral head.[8] This anterolateral branch of the ACHA and its subsequent branches in the mesotenon provide the main blood supply to the LHBT in this segment.[9-12] However, detailed knowledge about the vascular anatomy in the closed bicipital groove with the LHBT, the mesotenon and the transverse ligament still in place is sparse especially on a histological level as most studies evaluate either the blood supply to the segmented biceps tendon or to the dissected humeral head.[10-12]

The purpose of this histological study was therefore to further analyze the distinct vascular distributional pattern of arteries in the bicipital groove and the vascularization of this segment of the LHBT.

Materials and Methods

An anatomic dissection and histologic study was performed by using 24 cadaveric formaldehyde fixated shoulders. The mean age of the specimens was 82.6 years (range 61 to 96 years, 17 female). Dissection was conducted in a similar fashion for all specimens by the 2nd author.

The outer skin, subcutaneous tissues and the deltoid muscle were removed with the shoulder capsule, rotator cuff and LHBT sheath covered by the transverse humeral ligament left intact. Afterwards, the bicipital groove including the LHBT and its intact sheath is cut out en-bloc using chisels. The cranial border of the segmented block was defined the upper edges of tuberculum minus and majus and the distal border was defined by the insertion of the pectoralis major muscle. Laterally, the incision was placed 10 mm lateral to the LHBT to include the complete lateral wall of the osseous groove. Medially, 20 mm distance to the LHBT is kept in order to include the complete medial wall of the groove (Figure 1). A total of 24 bone blocks (each 25×30×12 mm) were obtained.

The blocks were then subsequently decalcified in diamine tetraacetic acid and embedded in paraffin. Each block was cut in 7 µm sections using an automated rotary microtome (Microm HM360, Thermo Fisher Scientific, Waltham, MA, USA). The sections are then stained according to a modified Heidenhain's Azan staining protocol. After staining, immersion of the sections in an ascending series of ethanol, mounting using a xylene miscible mountant (Depex, SERVA Electrophoresis GmbH, Heidelberg, Germany) and sealing of the slides for light microscopy was conducted. The histological evaluation was carried out using a standard light microscope (Motic, Wetzlar, Germany). The included microscope camera was used for documentation (Moticam 10.0 MP, Motic, Wetzlar, Germany) and the included software is used for measuring, scaling, and labelling. In the average 64±21.89, 7 µm sections are analyzed per specimen. Each branch deriving

Correspondence: Glyn Hamed, Heinrich-Heine-Universität Düsseldorf, Institut für Anatomie I, Universitätsstraße, 40225 Düsseldorf, Germany.
Tel.: +49.211.81.18314 - Fax: +49.211.81.16693.
E-mail: glyn.hamed@med.uni-duesseldorf.de

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from the main arteries in the mesotenon of the LHBT was identified and followed through multiple sections to identify its direction and area of supply (Figure 2).

Statistical analysis

IBM SPSS Statistics 23 (Armonk, New York, USA) was used for statistical analysis. Statistical significance was indicated at a significance level of $P<0.05$. The Chi-Square test was used for comparison of anatomical distribution of the branches to the medial and lateral wall of the groove.

Compliance with ethical guidelines

All authors declare that they have no competing interests. All procedures performed were in accordance with the American Association of Clinical Anatomists (AACA) Best Practices for Donor Programs and the 1964 Helsinki declaration and its later amendments. The local ethics committee approved this study (registration number 5096).

Results

The LHBT was identified surrounded by synovial and loose connective tissue. Anterior to the LHBT, the mesotenon containing ascending branches of the ACHA running alongside the LHBT can be identified. Intratendinous vessels could not be found in any specimen. The bicipital groove was covered with a thick fibrous roof representing the transverse humeral ligament whereas the posterior groove with contact to the LHBT is covered with fibrous cartilage (Figure 3). In addition, Pacini-like mechanoreceptors could be identified in the mesotenon in 9 (37.5%) of the specimens.

Per specimen, a mean of 2.71±1.85 arteries branching off the main ascending artery could be identified running through the soft tissue of the mesotenon towards the osseous walls of the groove. Of the total 65 arterial branches in all specimens, 22

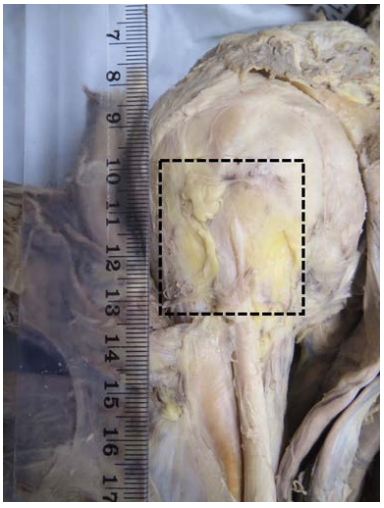

Figure 1. Humeral head after removal of the skin, subcutaneous tissues and the deltoid muscle revealing the shoulder capsule, rotator cuff and LHBT sheath covered by the transverse humeral ligament in the bicipital groove. A bone block (25×30×12 mm, dashed line) including the complete and intact bicipital groove is cut out for histological analysis.

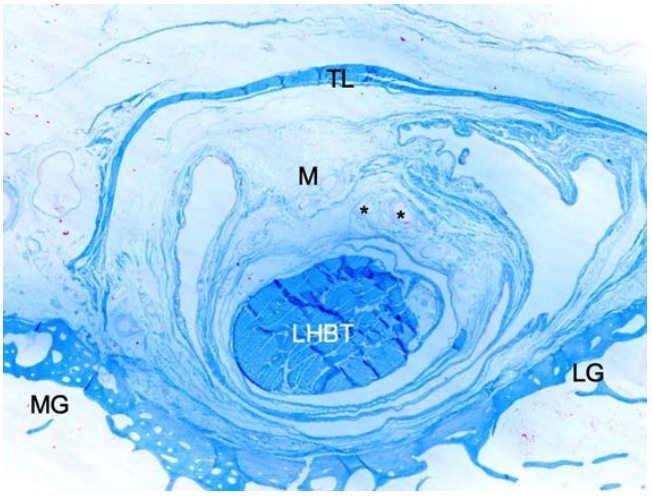

Figure 2. Azan stain of a transverse section through the bicipital groove. The osseous medial and lateral groove (MG; LG) contain the long head of biceps tendon (LHBT) surrounded by the mesotenon (M). Ascending arterial branches accompanying the tendon can be identified (*). The groove is covered by the transverse ligament (TL).

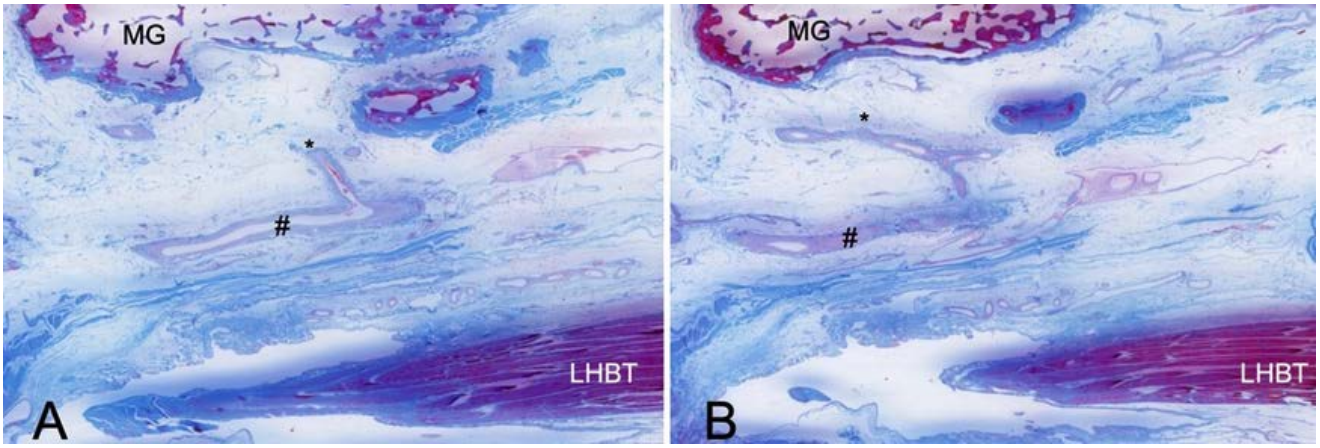

Figure 3. Azan stain of subsequent longitudinal sections. An artery (#) runs along the long head of biceps tendon (LHBT) with a branch (*) which can be followed through multiple sections (A, B) towards the osseous medial wall of the groove (MG).

(33.8%) were running into the medial wall of the groove and 40 (61.5%) into the lateral wall (P<0.01). For 3 branches (4.6%) a clear direction could not be identified.

In the bony wall of the bicipital groove, the arterial branches were found running inside canals with a mean diameter of 630±597.47 µm (range 83-3722 µm). The mean diameter of the arterial branch within those canals was 140±104.09 µm (range 45-556 µm). A nerve inside the osseous canal could be identified in 38 (58.4%), 18 (47.4%) of the nerves were found to be myelinated.

The mean diameter of the canals in the lateral groove was 596±513.92 µm (range 127-2676 µm) with an arterial branch with a mean diameter of 142±129.58 µm (range 45-556 µm). The mean diameter of the medial canals was 721±761.54 µm (range 83-3722 µm) with 141±62.61 µm (range 50-241 µm) for the arterial branch. An accompanying nerve was identified in 15 (39.4%) of the medial and 20 (52.6%) of the lateral canals (Table 1).

Discussion

The most important finding of the present study is that the ascending branches of the ACHA in the mesotenon of the LHBT provide blood supply not only to the LHBT but to the osseous bicipital groove as well. Concerning the distinct distributional pattern, we are able to show that the significantly more branches are directed to the lateral than to the medial wall of the bicipital groove. Our results of ascending arterial branches in the mesotenon confirm the findings of other authors.[9-13] According to Kolts *et al.* the distal portion of the LHBT is supplied by branches of the brachial and deep brachial artery and the proximal portion by branches of the ACHA.[10] Cheng *et at*. found an ascending branch of the ACHA entering the tendon surrounding mesotenon 4.5-6.5 cm distal from LHBT origin and providing blood supply to the LHBT in the groove.[12]

Boesmueller *et al.* confirmed by computed tomography angiography in cadaveric shoulder that the arterial supply of the LHBT in the bicipital groove always derived from an ascending branch of the ACHA.[11] In contrast, Determe *et al*. identified the main artery in the mesotenon as recurrent branch of the brachial artery in their gross anatomical study.[13]

One limitation of our study is that origin of arteries in the mesotenon was not identified by dissection prior to the histological analysis.

In regard to the blood supply to the osseous humeral head, Gerber *et al.* demonstrated that the anterolateral branch of the ACHA crossed under the LHBT and entered the humeral head directly to provide the main blood supply.[14] Hettrich *et al*. on the other hand report that the posterior humeral circumflex artery provides the majority of the blood supply.[7] Even though the amount of actual blood supply to the osseous groove and humeral head by arterial branches in the mesotenon has not been quantified in the present study, obliteration of the proximally directed blood supply for example by subpectoral biceps tenodesis seems not to have a considerable clinical impact.[15-18] This indicates that the blood supply by the branches ascending in the mesotenon, in contrary to the importance of the main anterolateral branch of the ACHA might not be of utmost clinical relevance for the osseous humeral head.

In addition, we identified Pacini-like mechanoreceptors in the soft-tissue of the mesotenon in 37.5% of the specimens. Numerous mechanoreceptors are found in the shoulder joint capsule, rotator cuff and the glenohumeral ligaments but have not been described in the soft tissue of the bicipital groove adjacent to the LHBT up to now.[19,20]

Snow et al histologically analyzed the transverse humeral ligament and found free nerve endings but no mechanoreceptors. However, their examination did not include the LHBT or the soft-tissue inside the groove.[21]

Even though not focus of the current study this accidental finding should be included in future studies to evaluate the detailed distributional pattern of mechanoreceptors in the bicipital groove and their relevance for pathologies of the LHBT.

Table 1. Overview of results.

Results	N.
Number of specimens	24
Age (median)	82.6
Male:female	7:17
Arterial branches from mesotenon to bone (total)	65
Branches per specimen (mean)	2.71
Lateral	40)
Medial	22
Indefinable	3
Diameter of osseous canals (mean)	630
Lateral	596
Medial	721
Diameter of arterial branch in the canal (mean), µ	140
Lateral	142
Medial	141
Nerve identified in the osseous canal (total),	35
Lateral	20
Medial	15

Conclusions

The branches of the ACHA in the mesotenon of the LHBT provide blood supply not only to the tendon but to the osseous bicipital groove as well and here significantly more to the lateral than to the medial osseous wall. Pacini-like mechanoreceptors can be found adjacent to the LHBT in the mesotenon.

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