Blood supply and vascularity of the glenoid labrum: Its clinical implications

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Abstract

Background: Tears of the glenoid labrum are common after dislocation of the glenohumeral joint. The outcome for healing or surgical reconstruction of the glenoid labrum relies on the extent of its vascularization. This study aims to evaluate the glenoid labrum blood supply and to determine its regional vascularity.

Materials and Methods: A total of 140 shoulders (30 male and 40 female cadavers) were examined: mean age 81.5 years, range 53–101 years. All blood vessels around the glenohumeral joint were dissected and recorded. Ten specimens with the glenoid labrum and fibrous capsule attached were randomly selected and detached at the glenoid neck and subjected to decalcification. Sections (10–20 μm) were cut through the whole thickness of each specimen from the centre of the glenoid fossa perpendicular to the glenoid labrum at 12 radii corresponding to a clock face superimposed on the glenoid. Sections were stained using haematoxylin and eosin and then examined.

Results: The blood supply to the glenoid labrum is by direct branches from the second part of the axillary artery, subscapular, circumflex scapular and anterior circumflex humeral and posterior circumflex humeral arteries, as well as branches of muscular arteries supplying the surrounding muscles.

Conclusion: This study shows that the glenoid labrum has a rich blood supply suggesting that, regardless of the types of the glenoid labrum lesions or their management, an excellent outcome for glenoid labrum healing and joint stability is possible. The observations also suggest that the blood supply to the glenoid labrum is sufficient, enabling its reattachment.

Keywords
axillary artery, blood supply, glenoid fossa, glenoid labrum, shoulder, suprascapular artery

Introduction

Tears of the glenoid labrum result in glenohumeral joint instability, which can also occur with glenohumeral dislocation.1 In a study of patients with their first glenohumeral dislocation and those with recurrent dislocation, Kim et al.2 noted that those with first-time dislocations/lesions of the glenoid labrum had a Bankart lesion (24.24%, n = 8), a free anterior glenoid labrum periosteal sleeve avulsion (ALPSA; 27.27%, n = 9), a bony Bankart lesion (12.12%, n = 4) and an adhesive ALPSA (3.03%, n = 1), while those with recurrent dislocations had a Bankart lesion (61.26%, n = 68), a free ALPSA (9.09%, n = 11), a bony Bankart lesion (11.71%, n = 13), an adhesive ALPSA

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(14.41%, n = 16) and a disruption lesion of the articular
glenoid (0.9%, n = 1). Lesions of the anteroinferior glenoid
labrum observed in first-time dislocation were found to
be 66.6% (n = 22) and in recurrent dislocations 98.1% (n = 109).

Several studies3–11 have reported a significant correla-
tion between labral fixation and glenohumeral translation.
In contrast, Kim et al.12 reported an insignificant correla-
tion between the extent of the labral lesion and the fre-
quency of glenohumeral dislocation.

The glenoid labrum increases the depth of the glenoid
fossa by 50%, with a Bankart lesion decreasing the depth to
50% anteriorly.13 Based on these observations, Howell and
Galinat13 assumed that the glenoid labrum plays a role in
stability. Pouliart and Gagey14 reported that the glenoid
labrum stabilizes the joint by preventing the humeral head
from shifting. Smith et al.15 and Williams16 added that it
protects the articular surface and aids joint lubrication. The
glenoid labrum contributes as much as 10–20% to the con-
cavity compression of the glenohumeral joint,17–20 and thus
the existence of an intact glenoid labrum is important for
concavity compression in joint stabilization. According to
Habermeyer et al.,21 while the glenoid labrum maintains
the negative intra-articular pressure inside the glenoid, it
also confers joint stability.

Despite the importance of the glenoid labrum and the
high incidence of associated lesions, its blood supply has
been rarely reported.22–25 Both Cooper et al.24 and Abras-
sart et al.22 reported that the glenoid labrum was supplied by
branches of teres minor and infraspinatus, as well as the
suprascapular, circumflex scapular and posterior circum-
flex humeral arteries, together with capsular and perioscal
branches, with the superior and anterosuperior labrum
being less well vascularized than the remainder. It is inter-
esting to note that no blood vessels were observed arising
from the underlying bone to supply the labrum. Later, many
nutrient foramina were present on the capsular circumfer-
ential ridge which supply the glenoid bone. The glenoid
labrum was found to be sparsely vascularized without any
particular pattern of distribution. Nevertheless, the vascu-
larity has been suggested to decrease with increasing age.23,25
Therefore, the aims of this study were to evaluate
the blood supply to the glenoid labrum and to determine its
regional vascularity.

**Material and methods**

One hundred and forty shoulders from 70 formalin-
embalmed cadavers (30 males, 40 females: mean age
81.5 years, range 53–101 years) were examined.

Skin and the superficial and deep fascia were completely
removed from the shoulder region. Anteriorly, the anterior
part of deltid and pectoralis major and minor were
cleaned, detached and reflected laterally to expose the bra-
chial plexus, brachial artery and its branches. Fibrous and
fatty tissue around and between the brachial plexus and its
branches, the axillary artery and its branches, and the axil-
rary vein and its tributaries was carefully removed by blunt
dissection; the brachial plexus was then removed. The short
head of biceps brachii and coracobrachialis were detached
from the coracoid process, reflected distally and removed.
The anterior circumflex humeral artery and its accompan-
ying veins were cleaned using blunt dissection.

A direct branch from the second part of the axillary
artery (named here the ascending glenoid artery and pass-
ing under the coracoid process towards the anterosuperior
and superior aspects of the shoulder joint) was dissected
and cleaned from proximal to distal.

Superiorly, trapezius was removed, while the proximal
attachments of the middle and posterior parts of deltid
were released, following which the clavicle was removed.
A lateral incision was made in the supraspinatus tendon
insertion and gently reflected medially. The suprascapular
neurovascular bundle was cleaned.

Posteriorly, infraspinatus and teres minor were sectioned
near their insertions and reflected medially. The branches of
the suprascapular vessels were then traced into the infraspinous
fossa.

Following abduction of the upper limb, teres major and
the superolateral aspect of subs capsularis were removed.
The posterior circumflex humeral artery and its branches
and the accompanying veins and the axillary nerve were
cleaned as they passed around the surgical neck of the
humerus inferior to the shoulder joint. The lateral head of
triceps was then removed and the long head was cleaned.

The subscapular artery and its branches and the subscap-
ular vein and its tributaries were cleaned from proximal to
distal. The circumflex scapular vessels and their branches
and tributaries were traced and cleaned.

Ten specimens with the glenoid labrum and fibrous cap-
sule attached were randomly selected, detached at the gle-
noid neck and subjected to decalcification: this enabled the
tissues to be sectioned and stained using standard tech-
niques utilizing paraffin wax embedding. Each specimen
was decalcified using either a decalcifier containing hydro-
chloric acid (10%) for 4 months or a rapid decalcifier (10%
of formic acid in distilled water) for 48 h. The tissue was
then washed in phosphate buffered saline and embedded in
paraffin wax using standard techniques. Sections (10–20
μm thickness) were cut through the whole thickness of each
specimen from the centre of the glenoid fossa perpendicular
 to the glenoid labrum at 12 radii corresponding to a
clock face superimposed on the glenoid. This resulted in
a triangular-shaped section of tissue with the glenoid lab-
rum and fibrous capsule attachment at the periphery. Sec-
tions were stained using haematoxylin and eosin.

**Results**

The blood supply to the glenoid labrum was observed and
noted during the dissection of all 140 shoulders. The lab-
rum receives its blood supply from:
The ascending glenoid artery (Figure 1), a branch arises from the first, second and third parts of the axillary artery in 1.80% \((n = 2)\), 92.50% \((n = 130)\) and 5.70% \((n = 4)\) of specimens, respectively: it was observed as a single branch in 91.40% \((n = 128)\), two branches in 7.9% \((n = 11)\) and three branches in 0.70% \((n = 1)\) of specimens, with the branches supplying subscapularis, the superior and anterosuperior aspects of the fibrous capsule, the glenohumeral ligaments, the superior and anterosuperior aspects of the glenoid labrum (Figure 2), glenoid neck, coracoid process, both heads of biceps brachii tendons and their origin, coracobrachialis and the rotator cuff muscle tendons.

The inferior glenoid artery, present in 82.85% \((n = 117)\) of specimens arising from the circumflex scapular \((54.7\%, n = 64)\) and subscapular \((15.4\%, n = 18)\) arteries (Figures 3 and 4).

Ascending branches of the anterior circumflex humeral artery supplying the superior and anterosuperior aspect of the glenoid labrum, the LHBT and the surrounding structures. LHBT: long head of biceps tendon.

The inferior glenoid artery, present in 82.85% \((n = 117)\) of specimens arising from the posterior circumflex humeral \((29.9\%, n = 35)\), circumflex scapular \((54.7\%, n = 64)\) and subscapular \((15.4\%, n = 18)\) arteries (Figures 3 and 4).

Ascending branches of the anterior circumflex humeral artery supplying the fibrous capsule and surrounding structures, contributing indirectly in supplying the glenoid labrum through its attachment to the joint capsule and adjacent bone (Figure 1).

Capsular branches of the posterior circumflex humeral artery, which in all specimens passed through the fibrous capsule from its anteroinferior, inferior, posteroinferior and posterior...
aspects running through the fibrous capsule for variable distances before entering the joint. These capsular branches also supplied subscapularis, the glenohumeral ligaments and fibrous capsule: As they passed medially through the fibrous capsule, the branches supplied the anteroinferior, inferior, posterior and posteroinferior aspects of the glenoid labrum.

v. The circumflex scapular artery which gave (a) capsular branches, seen in all specimens, supplying the anteroinferior, inferior and posteroinferior parts of the fibrous capsule and glenoid labrum, as well as the long head of triceps, subscapularis and teres minor; and (b) a branch present in 74.42% \((n = 104)\) of specimens, named an ascending branch arising from the circumflex scapular artery 30 mm from its origin, at the lower border of the origin of the long head of triceps, ascending superomedially posterior to the origin of the long head of triceps and grooving the bone for a short distance accompanied by two veins (sometimes one), which passed towards the inferior aspect of the spinoglenoid notch, then curved medially to run in the infraspinous fossa inferior to the root of the spine of the scapula terminating as several superior and inferior branches supplying infraspinatus and teres minor and as capsular branches supplying the posteroinferior, posterior, posterosuperior and superior aspects of the fibrous capsule, the glenoid rim and the glenoid labrum.

vi. The suprascapular artery, which gave (a) an articular branch in the supraspinous fossa running laterally posterior to the root of the coracoid process parallel to the anterior aspect of the supraspinatus tendon passing through the distal aspect of supraspinatus and the superior aspect of the fibrous capsule to supply the superior region of the glenoid labrum and the origin of the long head of biceps, giving periosteal branches to the superior aspect of the glenoid neck and nutrient branches to the superior aspect of the glenoid neck and the posterior part of the root of the coracoid process; this branch was present in 85% \((n = 119)\) of specimens; and (b) two or more branches were given in the spinoglenoid notch, which pierced the joint capsule from the posterosuperior and posterior aspects and supplied the posterior aspect of the supraspinatus tendon, fibrous capsule and glenoid labrum.

A summary of the regional blood supply to the glenoid labrum is shown in Figure 5.

Figure 5. Summary of the blood supply to the glenoid labrum. The circle represents the glenoid labrum. The blue region is supplied by ascending glenoid artery, the green region is supplied by anterior circumflex humeral artery, the red region is supplied by posterior circumflex humeral artery, the purple region is supplied by suprascapular artery and the yellow region is supplied by the subscapular and circumflex scapular arteries.

Histology

The glenoid labrum was fibrocartilaginous, being more fibrous at its free margin. It attached to the articular surface of the glenoid fossa centrally and glenoid bone peripherally. Some labral fibres also attached to the underlying glenoid bone, reaching as far as the bone marrow. In some regions, the fibrous capsule splits into an internal part, covering the internal aspect of the glenoid labrum, and an external part, covering the external aspect. The glenoid labrum was vascular with a variable distribution in the number and size of blood vessels in each region. Blood vessels were observed in the periphery with those from the fibrous capsule piercing the glenoid labrum (Figure 6).

Discussion

The blood supply to the glenoid labrum has been rarely reported.\(^{22-25}\) This study set out to address this and to determine whether there were regional differences in vascularity. Based on gross dissection, the current study indicated that (i) the superior and anterosuperior regions of the glenoid labrum receive an arterial supply from the ascending glenoid artery, articular branches of the suprascapular artery, peristeal branches of the circumflex scapular artery and muscular branches of subscapularis; (ii) the anteroinferior and inferior regions receive an arterial supply from peristeal branches of the circumflex scapular artery, muscular branches of triceps and subscapularis and the inferior glenoid artery, which itself can arise from either the posterior circumflex humeral, circumflex scapular or subscapular artery; and (iii) the posteroinferior and
posterosuperior regions receive an arterial supply from periosteal branches of the suprascapular artery, muscular branches of teres minor and infraspinatus and occasionally an ascending branch of the circumflex scapular artery through periosteal branches, as well as direct branches to these regions: branches of the anterior and posterior circumflex humeral arteries pierce the capsule anterosuperiorly, anteroinferiorly, inferiorly and posteroinferiorly supplying the anatomical neck, some of which also supply the fibrous capsule and glenoid labrum.

Histologically, Abrassart et al. 22 and Cooper et al. 24 reported that the anterosuperior region of the glenoid labrum was less vascular compared to other regions. The current study observed that the anterosuperior region of the glenoid labrum was rich in blood vessels, suggesting that it cannot be less vascular than other regions. Prodomos et al. 25 are of the view that the glenoid labrum is sparsely vascularized but reported no particular pattern of distribution.

The histological findings of the current study found that the glenoid labrum was anchored to the periosteal layer of the glenoid bone, which is known to be rich in blood vessels, therefore it would be expected that the glenoid labrum would have a blood supply from both the periosteal layer and the bone. Yoneda et al. 26 reported that the management of Superior Labral tear from Anterior to Posterior (SLAP) type II lesions by debridement of the detached glenoid labrum and abrading the glenoid rim until it bleeds, then fixing the glenoid labrum by staples, produced excellent or good results in 80% of patients.

It could be questioned if the blood supply to the glenoid labrum is sufficient to enable its reattachment. DaSilva et al. 27 reported the management of SLAP type II lesions is by debridement of both the superior glenoid labrum, using a shaver, and the bony bed, using a burr until it bleeds: Interestingly, this procedure has been critical because it provides an optimal healing environment at the bone-labral junction, which is anchored by a non-absorbable suture. According to Ok et al. 28 double anchor sutures for SLAP type II lesions provide better restoration and stability. A double-looped corkscrew anchor procedure has shown encouraging results for SLAP type II lesion. 29 Open Bankart repair with suture anchors associated with the capsular shift procedure was more effective in small Bankart lesions compared to large ones. 30 Kamath et al. 31 reported that two double-loaded suture anchors were better or equal to three single-loaded suture anchors because it needed fewer anchor holes in the glenoid bone, thus decreasing the incidence of postsurgical glenoid fracture. In patients who underwent an arthroscopic bony Bankart bridge to treat a Bankart lesion, there was an average glenoid bone loss of 29% (n = 14): Millett et al. 32 observed that successful joint stability was achieved in 93%. The current study has shown that the glenoid labrum has a rich blood supply, which supports the excellent outcomes of glenoid labrum healing and joint re-instability observed, regardless of the types of the glenoid labrum lesions or their management. 33–37,10 It is suggested that the blood supply to the glenoid labrum is thus sufficient to enable its reattachment. On the other hand, it could be questioned how and why incomplete or non-healing of labrum injuries occurs, leading to recurrent shoulder instability and poor blood supply to the glenoid labrum, such as in diabetic patients, which could impair healing of the glenoid labrum. 38

As this study was done on cadaveric shoulders and due to lack of medical history, only shoulders with completely attached glenoid labrum were subjected to histological investigation; therefore, this study was unable to investigate the blood supply in detached glenoid labrum due to shoulder pathologies. Further studies are recommended to investigate the blood supply in detached glenoid labrum.

It could be argued if there was any variation of the blood supply pattern that supply the glenoid labrum has been observed. The ascending glenoid artery which supplies the superior and anterosuperior aspects of the glenoid labrum showed anatomical variations in its origin and determined whether it was a single or multiple branches. It was observed to arise from the first, second and third parts of the axillary artery in 1.80%, 92.50% and 5.70% of specimens, respectively: it was observed as a single branch in 91.40%, two branches in 7.9% and three branches in 0.70% of specimens. The inferior glenoid artery which supplies the inferior aspect of the glenoid labrum was present in 82.85% of specimens arising from the posterior circumflex humeral (29.9%), circumflex scapular (54.7%) and subscapular (15.4%) arteries. Few shoulders were injected with coloured silicone aiming to evaluate the variation

**Figure 6.** (a) Low-magnification micrograph of the GL and fibrous capsule at the 10 o’clock position on the right side. (b) and (c) High-magnification micrograph showing BV. GL: glenoid labrum; BV: blood vessels.
pattern in arterioles and venules that supply the glenoid labrum, but the coloured silicone could not reach to these small blood vessels due to their narrow diameters.

Conclusion
The blood supply to the glenoid labrum can be summarized by dividing the glenoid labrum into six regions: superior, anterosuperior, anteroinferior, inferior, posteroinferior and posterosuperior. The superior and anterosuperior regions receive a blood supply from the ascending glenoid and suprascapular arteries as well as muscular branches of subscapularis and supraspinatus. The anteroinferior and inferior regions receive a blood supply from peristeal branches of the circumflex scapular and inferior glenoid arteries as well as muscular branches of triceps and subscapularis. The posteroinferior and posterosuperior regions receive a blood supply from periosteal branches of the suprascapular artery, muscular branches of teres minor and infraspinatus and occasionally an ascending branch of the circumflex scapular artery as well as branches of the anterior and posterior circumflex humeral arteries which pierced the capsule anterosuperiorly, anteroinferiorly, inferiorly and posteroinferiorly supplying the anatomical neck, some of which also supplied the labrum through the fibrous capsule. The glenoid labrum also receives a blood supply from the underlying glenoid bone. The current study suggests that, regardless of the types of the glenoid labrum lesions or their management, an excellent outcome of glenoid labrum healing and joint re-instability is possible. In conclusion, the blood supply to the glenoid labrum is sufficient to enable its reattachment.

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