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Vasculature of Anterior Cruciate Ligament – Review

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ABSTRACT

The anterior cruciate ligament (ACL) is one of the main ligaments of the knee joint, it resists anterior tibial translation and rotational loads. It is one of the most frequently injured structures during sports activities. Following the disruption of the ACL the stability of the knee joint will be deranged. The standard treatment for ACL injury was surgical reconstruction with graft because of the poor healing response of ACL with the primary repair. The tear involving the vascular region of the ACL can be treated with the native ACL and the tear involving the avascular region can be treated with graft. Therefore, knowledge about the ACL vascularity in the different zones could be helpful for the treatment of ACL injuries.

Keywords: Anterior cruciate ligament, primary repair, healing response

INTRODUCTION

The anterior cruciate ligament of the knee joint extends from the lateral femoral condyle to the anterior intercondylar region of the tibia. It is involved in the anterior and rotational translations of the tibia as well as; it acts as a secondary restraint to valgus stress. [1] The knee joint is more prone to injuries due to the active participation on sports activities. The anterior cruciate ligament is susceptible to injury more commonly than the other structures of the knee joint because, it prevents posterior displacement of the distal femur on the proximal tibia. The ACL is injured during sports activities during the rotation movements of the knee and as well as in semi-flexed knee position when the force is exerted anteriorly against the femur. [2] Replacement with graft has been followed as a treatment of choice for ACL injuries because of the poor healing capacity of ACL. [3] The vascularity studies of the ACL are sparse and results of earlier studies related to the microvasculature of ACL are controversial. Therefore, understanding the blood supply of ACL will improve the knowledge on the vasculature of ACL and also in improving the treatment options for ACL injury. This review includes the studies involving the vasculature of ACL.

The middle genicular artery from the popliteal artery provides the primary blood supply to ACL. A web-like network of periligamentous vessels cross the ligament transversely and anastomose with the longitudinally oriented intra-ligamentous vessels. The medial and inferior genicular arteries, arising from the posterior aspect of the popliteal artery, provide additional blood supply to the ACL. These arteries are embedded within the infrapatellar pad of fat, anastomose and give rise to the terminal branches that supply the distal portion of the ACL directly. [4–9]

MATERIALS AND METHODS:

The words, ACL and blood supply, ACL and vasculature were used as keywords for searching the

articles in PubMed for writing review. The articles in the English language and studies involving humans only were included. The articles in other languages and animal studies are excluded.

REVIEW:

The major blood supply to the cruciate ligaments arises from the middle genicular artery and the distal part of both cruciate ligaments is vascularized by the branches of the lateral and medial inferior genicular artery.

Toy et al. in 1995 did a study on two cadavers by using epoxy solution with lead oxide for CT Scan and fine dissection to visualize the arterial pattern of ACL. They stated that ACL received its primary blood supply from the middle genicular artery, adjacent synovium, inferior medial and lateral genicular arteries. The middle genicular artery, a branch of popliteal artery runs on the dorsal aspect of ACL provides ligamentous branches to the ACL. These branches form the network of vessels which gives rise to the connecting branches. They cross the ACL transversely and anastomose with the longitudinally running intra-ligamentous vessels. The primary connection was between the transverse running vessels with the intra-ligamentous vessels near the attachment site. The proximal vessels are larger compared with the distal vessels. They concluded that the middle zone of the ACL has less vascular supply compared to the proximal and distal zones and specified that terminal portions of the ACL were more vascularized and no avascular zones in the ACL. The inferior medial genicular artery coursed below the medial condyle of tibia, passing deep to the tibial collateral ligament. The inferior lateral genicular artery runs proximal to the fibular head and deep to the fibular collateral ligament at the level of the joint line. Then it is embedded in the infrapatellar pad of fat. The distal portion of ACL was eventually supplied by the terminal branches from the inferior genicular arteries. Kennedy et al described the vessels inside the ACL were tortuous in nature to withstand the demand of ligament during the movements of the knee joint. [4]

Scapinelli R in 1997 described the presence of proximal and distal avascular zones. He studied the vasculature of cruciate ligaments and other associated structures using radiology and histology. He resected the knee joint after perfusion with the barium sulphate solution. He sectioned the knee joint in the coronal and sagittal plane after a series of process such as fixation with 10% neutral formalin followed by freezing and decalcification. Then the sections were radiographed. He used the same sections for spalteholz technique. He also described the course of the middle geniculate artery as well as its anatomic variation. The middle geniculate artery arises from the popliteal artery at the level of the proximal contour of femur condyles. In its extracapsular course, it is immersed in the fat present in the popliteal region with the outer diameter of about 1.5−1.8mm. Then it pierces the openings in the oblique popliteal ligament. It enters the knee joint cavity by traveling through the posterior capsule and ends in the intercondylar fossa of the femur. In the knee joints, the artery ramifies and supply the anterior cruciate ligament. The descending intracapsular, subsynovial branches from the middle geniculate artery runs an oblique or horizontal course over the entire length of ACL. The upper part of ACL was supplied by the collateral branches from the arteries supplying lateral femoral condyle and the roof of the intercondylar notch. The lower part of ACL was supplied by infrapatellar ramifications of the inferior geniculate artery. He studied the cruciate ligament vasculature by sectioning in the horizontal plane. The blood vessels after an endoligamentous distribution, they divide into upward or downward in a longitudinal direction parallel to collagen fascicle. The endoligamentous vessels were lodged in the interfascicular septa. The blood vessels in the proximal and middle portion have a descending course and the distal portion have an ascending course. The junction of these two areas was found to be less in vascular supply and avascular zone near the proximal and distal attachments consists of only of chondroid tissue. [5,6]

Marshall et al. in 1979 reported, inferior and superior middle genicular arteries enter the knee joint anteriorly and posteriorly. They give branches to the infrapatellar pad and the surrounding synovial tissues. The paraligamentous vessels surround the ligament and give rise to smaller connecting branches that penetrate the ligaments transversely and anastomose with a longitudinal network of endoligamentous vessels, While the middle geniculate artery gives off additional branches to the distal femoral epiphysis

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and proximal tibial epiphysis. They noted that the ligamentous osseous junctions of the cruciate ligaments do not contribute significantly to the vascular supply of the ligaments. [7]

Peterson et al. reported the presence of an avascular area in the distal part of the ligament. They demonstrated the vascular supply of ACL using old methods and another new method with immunohistochemical staining using laminin of the basement membrane as an antigen. They also identified the presence of blood vessels over the surface of ACL using injection method with indian ink gelatin solution. They explained that the major blood supply of ACL is from the middle geniculate artery and in addition the inferior geniculate artery supplies the distal part of ACL. The branches from these arteries form a web-like network of peri-ligamentous vessels. They mentioned the area of the avascular zone of about 0.5 cm proximal to the tibial insertion on the anterior portion of ACL. The reason for the avascularity of ACL may be due to the contact of ACL with the notch during the full knee extension. Peterson et al confirmed the findings obtained from the injection techniques with the immunohistochemical techniques. The periligamentous blood vessels enter the ACL in a horizontal direction and anastomose with the longitudinal vessels located in the loose connective tissue and the intraligamentous blood vessels are less compared with the periligamentous vessels. [8]

Hetsroni I. et al. in 2016 described the ACL vasculature in different age groups by using arthroscopy. They compared the vascularity of ACL with the chondral lesions of the knee joint. The vascularity of ACL was observed in patients younger than the 30 yrs. Avascular ACL was observed in the patient's age more than 60 yrs. The avascular zone only in the central region was seen in the age group of 40 to 49 years. They considered the narrow notch impingement leads to the disruption of periligamentous vasculature which may result in the avascularity of ACL. [9]

Figure 1 shows the schematic diagram of vasculature on different zones of anterior cruciate ligament. Table 1 describes comparison of reported studies on vasculature of ACL.

CONCLUSIONS:

The vascular supply of ACL is derived from the small branches of the major blood vessels, synovium and infrapatellar pad of fat. The preservation and utilization of these tissues should be considered when repair or reconstruction of the anterior cruciate ligament is being performed. The density of blood vessels within the ligaments is not homogeneous. In the ACL, an avascular zone is located within the anterior part where the ligament faces the anterior rim of the intercondylar fossa. The coincidence of poor vascularity and the presence of fibrocartilage in areas that are subjected to compressive loads, these two factors undoubtedly may play a role in the poor healing potential of the ACL. This review will be helpful in improving the knowledge on the vascularity of the different zones of the ligament.

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Table 1: Reported studies on vasculature of anterior cruciate ligament

Authors	Year	Type of study	No of sample	Method of study	Results	
					Vascular zone	Avascular zone
Marshall et al	1979	cadaver	-	Indian ink Injection method	Entire ACL	Ligamentous-osseous junction (Avascular)
Toy et al	1995	cadaver	2	CT scan and Dissection	Terminal Zone	Middle zone is less vascular
Scapinelli R	1997	cadaver	20	Radiography/ Indian ink injection method /Histology	Proximal, middle zone and distal zone	1. Junction of Middle and distal zone less vascular 2. Near the attachment site
Peterson et al	1997	cadaver	5	Injection method by Indian ink/ Immunohistochemistry	Proximal, middle zone and distal zone	Avascular zone about 0.5 cm from the distal attachment
Hetsroni I et al	2016	Patients	702	Knee Arthroscopy	Entire zone vascular: younger than 30 yrs.	Middle zone avascular: age more than 60yrs, Central region avascular: 40 – 49 yrs

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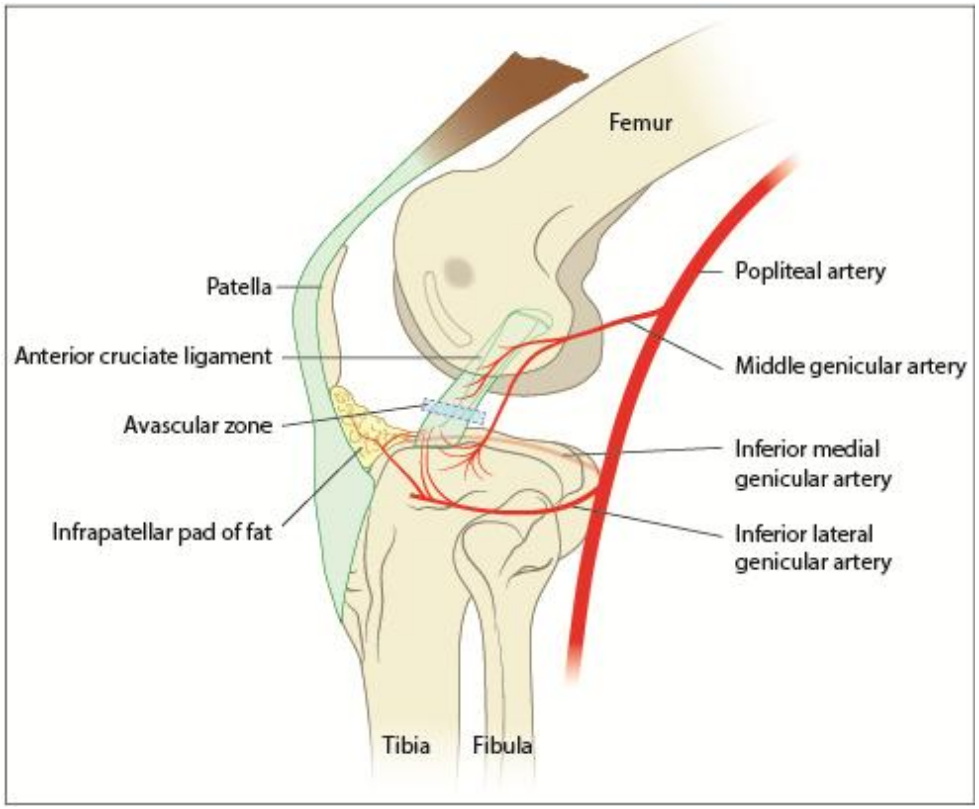
Figure 1: Schematic diagram illustrating the vascular distribution of Anterior cruciate ligament



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