Introduction

One of the earliest descriptions of the menisci was recorded by **Bland-Sutton in 1897.** At that time, the menisci were thought to be vestigial tissue and were depicted as "the functionless remnants of intra-articular leg muscles." Further advances in our understanding of the menisci have demonstrated that the menisci provide mechanical support and secondary stabilization, localized pressure distribution and load sharing, and lubrication and propioception to the knee joint ***(Maak et al., 2012).***

Historically, the indications and surgical techniques for excision of torn menisci have been controversial, orthopedic surgeons have advocated total excision of the torn meniscus, while others have proposed subtotal excision. Justification for total excision was often based on short-term & functional recovery criteria. When longer follow-up was studied, increasing degenerative changes were noted, especially if total meniscectomy was performed ***(Beamer et al., 2015).***

The vascular supply to the meniscus determines its potential for repair. The experimental findings have demonstrated that the peripheral meniscal blood supply is capable of producing a reparative response similar to that observed in other connective tissues ***(Becker et al., 2002).***

Many changes had been observed in the knee, alone or in combination, in patients at intervals ranging from 3 months to 14 years after meniscectomy as: an anteroposterior ridge projecting distally from the margin of the femoral condyle, flattening of the peripheral half of the articular surface of the condyle, and narrowing of the joint space. These changes were a result of the loss of the weight-bearing function of the meniscus ***(Miller, 1998).***

Arthroscopically-aided meniscal repair was first reported by ***Ikeuchi (1979)***; ***Grant et al. (2012); Wang et al. (2010); Choi et al. (2009),*** and others have reported high rates of success with meniscal repair.

Numerous classifications of tears of the menisci have been proposed based on location or type of tear, etiology, and other factors. Whereas it is recognized that tears are more common when degenerative changes, cystic formations, or congenital anomalies are present, most of the commonly used classifications are according to the type of tear found at surgery. These are (1) longitudinal tears, (2) transverse and oblique tears, (3) combination of longitudinal and transverse tears (complex tears), (4) tears associated with cystic menisci, and (5) tears associated with discoid menisci ***(Miller, 1994)***.

Tears of greater than one centimeter in length oriented in a vertical longitudinal direction, and located in the periphery of the meniscus fall into the repairable category ***(DeHaven and Bronestin, 1997)***.

The most common criteria for meniscal repair include a vertical longitudinal tear greater than 1 cm in length located within the vascular zone. Tears in the red-red zone (1-3 mm from the menisco-synovial junction) and red-white zone (3-5 mm from the menisco-synovial junction) have excellent healing potential. The tear also should be unstable and displaceable into the joint. In addition, the patient should be active and less than 40 years old. The knee should be either stable or will be stabilized with a ligamentous reconstruction simultaneously. Finally, the bucket handle portion and the remaining meniscal rim should be in good condition ***(Miller, 1998).***

Aim of the Work

Aim of the work is to evaluate clinical healing of the medial meniscus after repair wether by all inside technique (fast fix anchors) or inside out (suturing) technique, and to find the best way for arthroscopic menisceal repair.

Review of Literature

The menisci have reached their highest level of development in humans. Their function is essential to the normal function of the knee joint, various functions have been attributed to the menisci, some of which are known or proved, others theorized ***(Miller, 1998).***

Meniscal injury is a major cause of functional impairment of the knee. While for many years the meniscus was treated with disrespect as an unnecessary appendage that could be sacrificed with the first hit of malfunction ***(Moseley et al., 2002)***.

As long term results after major meniscectomy were disappointing, a conservative clinical approach to the management of meniscal tears has developed over the past two decades, as the menisci play important roles in weight bearing, stabilization and energy absorption. In recent decades, a shift towards meniscal preservation has lead to the development of new surgical techniques ***(Cameron and Saha, 1997)***.

Three changes had been observed in the knee, alone or in combination, in patients after meniscectomy: (1) an antero-posterior ridge projecting distally from the margin of the femoral condyle, (2) flattening of the peripheral half of the articular surface of the condyle, and (3) narrowing of the joint space. These changes were a result of the loss of the weight-bearing function of the meniscus, and therefore meniscectomy can no longer be considered an entirely harmless procedure ***(Miller, 1998).***

Applied anatomy

To understand meniscal pathology, it is important to know the basic embryological and vascular features of the meniscus. Both the lateral and medial menisci assume their characteristic shapes early in prenatal development. The characteristic shape of the lateral and medial menisci is attained between the 8th and 10th week of gestation ***(De-Haven, 1999).***

In 1897, Bland-Sutton described the menisci as "functionless remnants of intra-articular leg muscles" in Ligaments: their nature and morphology ***(Maak et al., 2012).***

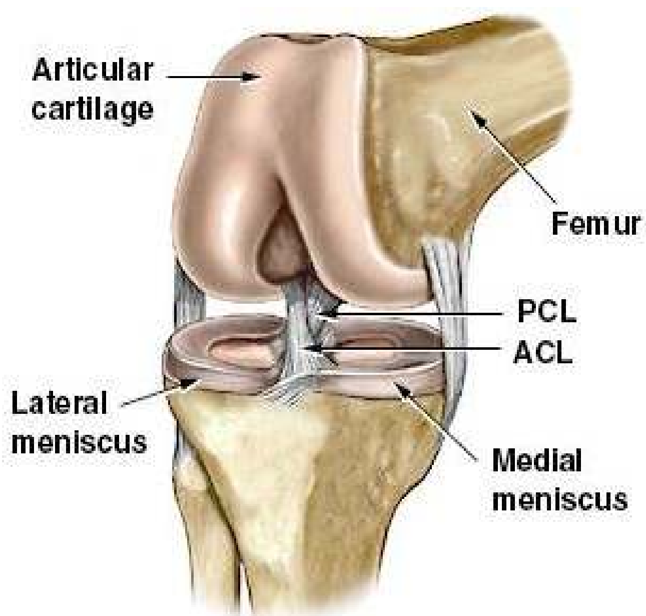

Fig. (1): The anatomy of the knee joint ***(Fox et al., 2012).***

The knee meniscus is crescent-shaped wedge of fibrocartilage present within the knee joint, situated between each femoral condyle and tibial plateau. Also known as 'semi-lunar' cartilage. The word *meniscus* comes from the Greek word *mēniskos*, meaning "crescent," diminutive of *mēnē*, meaning "moon" ***(fig. 1) (Fox et al., 2012).***

The medial meniscus is **C** shaped measures approximately 35 mm in diameter (anterior to posterior). The anterior horn is attached to the tibia plateau near the intercondylar fossa anterior to the anterior cruciate ligament (ACL). The posterior horn is attached to the posterior intercondylar fossa of the tibia between the lateral meniscus and the posterior cruciate ligament (PCL). The medial meniscus is more firmly attached to the femur through a condensation in the joint capsule known as the *deep medial collateral ligament*. It is attached to the lateral meniscus by "intermeniscal," ligament ***(fig.2) (Fox et al., 2012).***

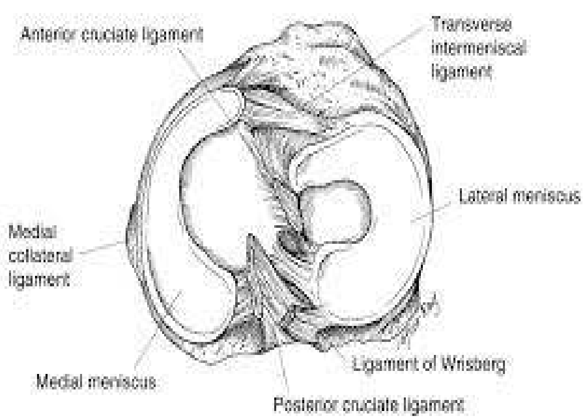

Fig. (2): Axial view for both menisci & menisco femoral ligaments ***(Fox et al., 2012).***

The lateral meniscus is smaller and more circular and covers a larger portion of the articular surface than the medial meniscus does. The posterior horn is connected lateral to the medial epicondyle of the femur via Wrisberg or Humphrey ligament. Although being attached to the articular capsule and the tibia, it is separated posterolaterally from the capsule by the popliteus tendon and thus is more mobile compared to the medial meniscus ***(Jeong and Lee, 2012).***

Microscopic observation of the meniscus shows a fibrocartilaginous tissue made up of fibroblasts and chondrocytes. The fibrocartilage tissue synthesizes extracellular matrix that is composed of water (72%) and predominantly type I collagen (90-95%), type II, type III, type V, and the predominance of type I collagen distinguishes the fibrocartilage of the meniscus from the articular (hyaline cartilage) ***(fig.3) (Vanderhave et al., 2011).***

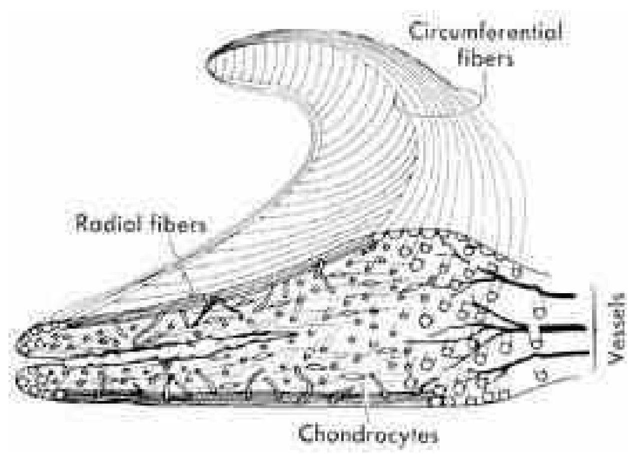

Fig. (3): Microscopic anatomy of the meniscus ***(Vanderhave et al., 2011).***

Proteoglycans in the extra cellular matrix (ECM) are responsible for hydration and provide the tissue with a high capacity to resist compressive loads. The glycosaminoglycan profile of the normal adult human meniscus consists of chondroitin-6-sulfate (40%), chondroitin-4-sulfate (10% to 20%), dermatan sulfate (20% to 30%), and keratin sulfate (15%) The highest glycosaminoglycan concentrations are found in the meniscal horns and the inner half of the menisci in the primary weight bearing areas ***(Fox et al., 2012).***

The orientation of collagen fibers is mainly circumferential with some radial and perforation fibers. The predominance of circumferential fibers in the outer one third of the meniscus is effective for distribution of hoop tension that develops due to weight bearing. The type I fibers are oriented in a more radial direction. Radially oriented "tie" fibers are also present in the deep zone and are interspersed or woven between the circumferential fibers to provide structural integrity ***(fig.3, 4) (Fox et al., 2012).***

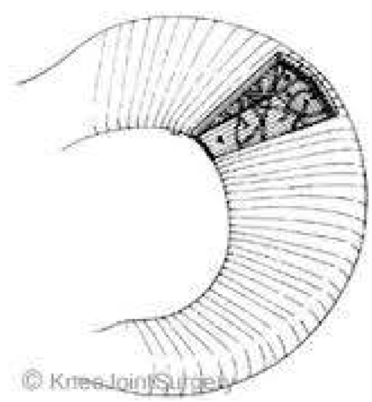

Fig. (4): Schematic diagram demonstrating the collagen fiber ultrastructure and orientation within the meniscus: 1, superficial network; 2, lamellar layer; 3, central main layer ***(Fox et al., 2012)***.

The meniscus is a relatively avascular structure with a limited peripheral blood supply. The medial, lateral, and middle geniculate arteries (which branch off the popliteal artery) provide the major vascularization to the inferior and superior aspects of each meniscus. A premeniscal capillary network arising from the branches of these arteries originates within the synovial and capsular tissues of the knee along the periphery of the menisci. The peripheral 10% to 30% of the medial meniscus border and 10% to 25% of the lateral meniscus are relatively well vascularized, which has important implications for meniscus healing.

The remaining portion of each meniscus (65% to 75%) receives nourishment from synovial fluid via diffusion or mechanical pumping ***(fig.5) (Spindler et al., 2003).***

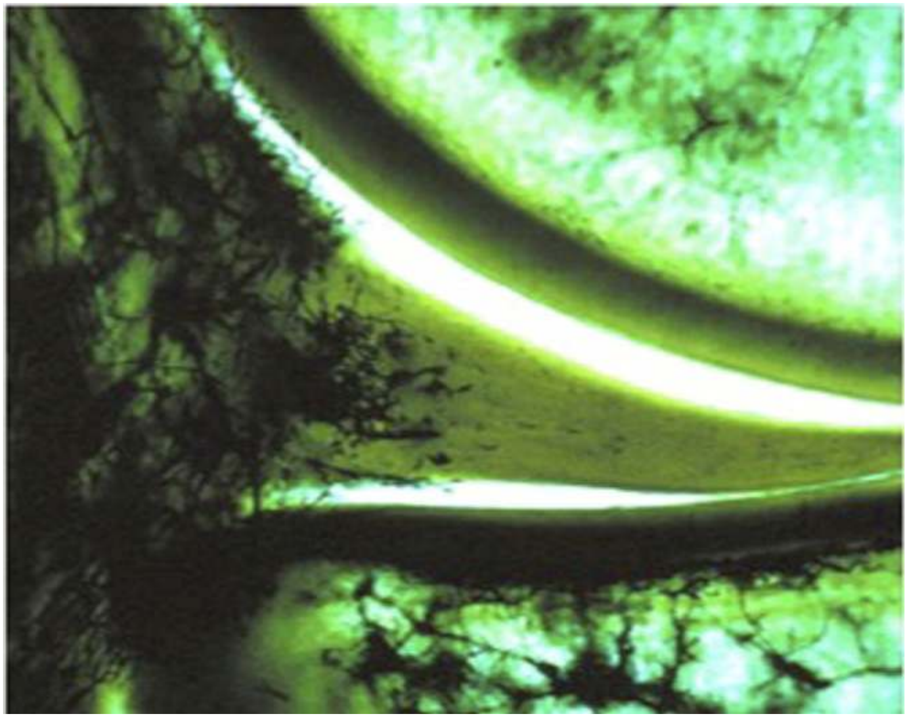

Fig. (5): Cross-sectional vasculature of the meniscus shows vascular supply to the peripheral 30% of the meniscus and the clear transition between red-red, red-white, and white-white zones ***(Spindler et al., 2003).***

The knee joint is innervated by the posterior articular branch of the posterior tibial nerve and the terminal branches of the obturator and femoral nerves. The lateral portion of the capsule is innervated by the recurrent peroneal branch of the common peroneal nerve. These nerve fibers penetrate the capsule and follow the vascular supply to the peripheral portion of the menisci and the anterior and posterior horns, where most of the nerve fibers are concentrated ***(Choi et al., 2014).***

The perception of joint motion and position (proprioception) is mediated by mechanoreceptors that transduce mechanical deformation into electric neural signals. Mechanoreceptors have been identified in the anterior and posterior horns of the menisci. Quick-adapting mechanoreceptors, such as Pacinian corpuscles, are thought to mediate the sensation of joint motion, and slow-adapting receptors, such as Ruffini endings and Golgi tendon organs, are believed to mediate the sensation of joint position ***(Lambordo et al., 1999).***

With advancing age, the meniscus becomes stiffer, loses elasticity, and becomes yellow. Microscopically, there is a gradual loss of cellular elements with empty spaces and an increase in fibrous tissue in comparison with elastic tissue. These cystic areas can initiate a tear, and with a torsional force by the femoral condyle, the superficial layers of the meniscus may shear off from the deep layer, producing a horizontal cleavage tear ***(Furumatsu et al., 2014).***

Biomechanics of the meniscus

Weight bearing produces axial forces across the knee which compress the menisci, resulting in “hoop” (circumferential) stresses. Hoop stresses are generated as axial forces and converted to tensile stresses along the circumferential collagen fibers of the meniscus. Firm attachments by the anterior and posterior insertional ligaments prevent the meniscus from extruding peripherally during load bearing. It was reported that 70% of the load in the lateral compartment and 50% of the load in the medial compartment is transmitted through the menisci ***(Lin et al., 2013).***

Both menisci are displaced slightly forward in full extension and move back word when flexion proceeds. The anchorage of the medial meniscus permits less mobility than of the lateral meniscus, possibly explaining why injuries are more common to the medial meniscus. The action of the popliteus tendon laterally and the semimembranouses medially retracting the menisci posteriolly to protect them from being entrapped during knee movement ***(Robert et al., 2008).***

Biomechanics of repaired meniscus:

The kinematics of the repaired meniscus is significantly different than that of the intact and torn meniscus. The inner portion no longer translates posteriorly, as it did in the intact and torn state, but rather has minimal anterior movement like the outer portion. The outer portion also translates anteriorly and to a greater degree than the inner portion. Although this creates a compressive force in the midposterior region, the overall movement of the meniscus is anterior after a repaired meniscus, compared with a posterior direction when intact. This may be due to the increased rigidity that nonabsorbable sutures create. The meniscus, previously a malleable and somewhat mobile structure that can conform to the femur as it flexes, becomes a rigid, immobile structure that the femur rolls over like a car wheel rolling over a rigid speed bump on the road ***(Pujol et al., 2015; de Albronz and Forriol, 2012).***

Function

The major functions of the menisci are: increasing stability for femorotibial articulation, distribute axial load, absorb shock ***(Cannon, 1999).***

The menisci may also play a role in the nutrition and lubrication of the knee joint. There is a system of microcanals within the meniscus located close to the blood vessels, which communicates with the synovial cavity; these may provide fluid transport for nutrition and joint lubrication ***(Cannon, 1999).***

Mechanism of injury

A meniscus is usally torn by a rotational force incurred while the joint is partially flexed. During vigorous rotation of the femur on the tibia with the knee in flexion, the femur tends to force the medial meniscus posterioly and toward the center of the joint. A strong peripheral attachment posterioly may prevent the meniscus from being injured, but if this attachment stretches or tears, the posterior part of the meniscus is forced towards the center of the joint , is caught between the femur and the tibia, and is torn longitudinally when the joint us suddenly extended ***(Barret et al., 1998).***

Biology of meniscal healing

Although the vascular supply of the meniscus is an essential element in determining its potential for repair, Clinical and experimental observations have demonstrated that the peripheral blood supply is capable of producing a reparative response similar to that observed in other connective tissues. After injury within the peripheral vascular zone, a fibrin clot forms that is rich in inflammatory cells. Vessels from the peri-meniscal capillary plexus proliferate through this fibrin scaffold, accompanied by the proliferation of undifferentiated mesenchymal cells. Eventually, the lesion is filled with a cellular, fibro-vascular scar tissue that bonds the wound edges together and appears continuous with the adjacent normal meniscal fibro-cartilage. Vessels from the peri-meniscal capillary plexus, as well as the proliferative vascular pannus from the "synovial fringe," penetrate the fibrous scar to provide a marked inflammatory response. Experimental studies have shown that meniscal lesions extending to the synovium are completely healed with fibro-vascular scar tissue by 10 weeks. Modulation of this scar into normally appearing fibro-cartilage, however, can require several months ***(Rath and Richmond, 2000)***.

A decline in healing rates was reported as tear location moved from peripheral to central: 90% for tears within 2 mm of the periphery 74% for tears within 3 mm of the periphery, and