MENISCUS (A KRYCH, SECTION EDITOR)

Discoid Lateral Meniscus

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Abstract

Purpose of Review Discoid lateral meniscus (DLM) is a well-known meniscus variant, and comprises excess and thickened meniscal tissue, altered collagen ultrastructure, and peripheral instability. This article presents a comprehensive review on current knowledge of DLM, focusing on pathology in parallel with surgical techniques and outcomes.

Recent Findings A paradigm shift in surgical management of DLM is taking place as knee surgeons are seeing more patients with long-term sequelae of partial lateral meniscectomy, the standard treatment for DLM for many years. Surgical treatment has evolved alongside the understanding of DLM pathology. A new classification system has been proposed and optimal surgical techniques described in recent years. This article highlights up-to-date evidence and techniques in management of both acute DLM tears and joint restoration following subtotal meniscectomy for DLM.

Summary Surgical management of DLM must be tailored to individual pathology, which is variable within the diagnosis of DLM. We present an algorithm for management of DLM and discuss future directions for the understanding and treatment of this debilitating condition.

Keywords Discoid · Meniscal repair · Meniscal transplantation · Knee preservation

Introduction

Discoid meniscus is a common meniscus variant that can become symptomatic at any age. The true prevalence is unknown as discoid menisci are often asymptomatic [1•, 2]. Estimated as present in 4–5% of the population [3], discoid lateral meniscus (DLM) is not yet fully understood in both etiology and comprehensive pathology. Epidemiologic data has shown incidence of symptomatic DLM as 3.2 per 100,000 person-years [1•]. As a result, management strategies are widely variable and outcomes unreliable. First described in 1889 [4], "discoid meniscus" refers to thickened meniscal tissue with abnormal mobility/peripheral stability [5–8]. The pathology can be simplified into three "**S**'s" of the discoid meniscus: **S**ize, **S**tability and microscopic **S**tructure.

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Discoid menisci are hyperthickened (Size). They often have compromised peripheral Stability. Lastly, discoid menisci have abnormal collagen (Structure). These all play a role in the clinical challenges posed by the DLM.

Classification

The Watanabe classification system is the most frequently utilized in the literature [9]. The Watanabe classification describes three types of DLM: complete being full disk morphology covering the entire tibial plateau, incomplete being increased width but still in semilunar shape, and Wrisberg ligament variant being normal or thickened lateral meniscus that is lacking peripheral attachments of the posterior horn (coronary ligaments), stabilized posteriorly only by the Wrisberg meniscofemoral ligament. A more recent classification system has been described in light of possible overlap between complete/incomplete and Wrisberg ligament type menisci: specifically that the meniscus can be thickened while also having peripheral instability. This classification system was established by the Pediatric Research in Sports Medicine (PRiSM) organization and subclassifies based on four main elements of DLM: meniscal width, meniscal height, peripheral stability, and meniscal tear. Width is

classified as W0 to W2 (normal to near complete > 90% of plateau coverage respectively). Height is H0 or H1 (normal height or thicker than normal height, respectively). Stability is classified as S0 describing no instability, SA anterior half instability, SP posterior half instability, and SAP with both. Regarding tear classification, T0 denotes no tear. THA/THP describe horizontal tears in anterior or posterior meniscus. THAP describes a horizontal tear throughout anterior and posterior tissue. TDA/TDP/TDAP is the same anatomic locations with degenerative/complex/radial tearing [10]. While descriptive, no classification system to date has been able to prognosticate natural history or surgical outcomes.

Natural History

Incidence of contralateral DLM has been reported from 72% [11, 12] to 97% [13]. It has been reported that 17% of patients after surgery for DLM will ultimately undergo surgery on the contralateral knee [11]. Additionally, DLM does seem to does seem to have a variable association with osteochondritis dissecans of the lateral femoral condyle [14–18].

Pathophysiology

The presence of thickened meniscal tissue is congenital [4], however the underlying reason for peripheral instability associated with the DLM is not yet clear. Theories include congenital absence of coronary ligaments, or peripheral ligament failure from repetitive loading and excessive shear stress incurred by the thickened meniscus. It is possible that both conditions exist.

In addition to the morphological abnormalities of thickening and peripheral instability, the structural integrity of the DLM differs from the normal meniscus. The collagen has been found to be both quantitatively and qualitatively inferior to non-discoid lateral menisci [19••, 20••, 21]. In a histological study, circumferential fibers in DLM were distorted with significant myxoid degeneration, voids, and metaplasia, as well as heterogeneic organization, most markedly affecting the posterior horn compared to the homogeneous collagen organization in non-discoid menisci [20••]. It is not yet clear whether the thickened yet brittle meniscus leads to peripheral instability from increased shear stress at the meniscocapsular junction, or if the peripheral meniscocapsular insufficiency leads to hypermobility and increased tearing rates of the DLM. This abnormal microstructure and collagen may portend inferior outcomes when standard meniscal surgical treatments are applied to this non-standard tissue.

Clinical Presentation

Presentation of DLM varies and may not present until adulthood. Clinical awareness should be present in the setting of a child with a flexion contracture, atraumatic lateral pain, or

meniscus tears resulting from relatively low energy injuries. Patients typically present with lateral knee pain with or without mechanical symptoms. Physical exam comprises standard evaluation of the entire lower extremity with meniscal testing. In the case of an unstable DLM, an audible and or visible clunk may result during range of motion testing. If the DLM is fixed in a displaced position or very large, it may cause a motion limiting block. The presence of swelling is common but not always present. Lateral joint line tenderness is the most typical physical exam finding.

Imaging

Plain radiographs may demonstrate squaring of the lateral femoral condyle, concavity of the lateral tibial plateau, increased lateral joint space, and/or hypoplasia of the lateral tibial spine. The presence of all four findings carries a 76% positive predictive value for DLM in children aged 10–16 years of age [22]. However, a normal x-ray is often the case and should not rule out the presence of a DLM (Fig. 1). Magnetic resonance imaging (MRI) will show a universal, yet variable, amount of excess meniscus tissue. As described earlier, the DLM may also show thickening in the form of increased height either centrally or throughout. There is often increased intrasubstance signal within the meniscus. This is often mistaken for a horizontal cleavage tear as it appears as a horizontal increased T2 signal within the meniscus, but more likely represents the increased water content and myxoid degeneration characterized in DLM (Fig. 2). The presence of tears and/or peripheral instability is also variable and requires thorough evaluation of sagittal and coronal series).

When to Treat

Surgical intervention for DLM has the following indications: symptomatic tears, symptomatic instability and persistent pain with or without mechanical symptoms (i.e. flexion

Fig. 1 Anteroposterior radiograph of the left knee of a skeletally mature patient demonstrating all four radiographic findings of DLM: squaring of the lateral femoral condyle, concavity of the lateral tibial plateau, increased lateral joint space, and hypoplasia of the lateral tibial spine

Fig. 2 MRI T2 coronal×2 and sagittal images demonstrating a skeletally mature patient with DLM. Increased T2 signal seen within the meniscal tissue as a horizontal strip represents intrasubstance degeneration with myxoid tissue. This is seen most clearly on T2 images due to increased water content due to structural dysregulation within the meniscal tissue. Hypoplasia of the lateral femoral condyle is also appreciated

contracture in a child). Pain without tearing or instability should be elucidated from more common causes of knee pain such as patellofemoral pain or distal iliotibial band syndrome. These patients may require a course of physical therapy, steroid injections, etc. prior to surgery to rule out other causes of pain before surgical intervention is warranted. The presence of DLM alone without symptoms does not warrant surgical intervention, however the patient should be counseled regarding risk of tearing if incidentally observed on imaging and/ or for the contralateral knee.

Surgical Techniques

Surgical techniques are varied and outcomes unreliable due to altered tissue quality and meniscal hypermobility. Surgical techniques have advanced alongside our understanding of discoid pathology. Complete excision with total meniscectomy was reported from the 1960s to the 1980s [23], with poor long-term outcomes [24, 25] and is something that should be avoided if at all possible. Repair was first described in 1990 [26] and this has become an important element of management of DLM.

Arthroscopic management is universal at this point with general principles of creating a normal, or more normal, volume of meniscus tissue, repairing tears, and restoring stability with the goal of maximizing durability and joint preservation.

Intrasubstance degeneration (ID) is an important factor for the operating surgeon to consider in management of DLM. ID will typically be revealed once saucerization is begun and the inner substance of the meniscus is exposed. This abnormal tissue is well demonstrated in arthroscopic images in Fig. 3. ID is often misinterpreted as a horizontal cleavage tear on both MRI and intraoperatively, however it is important to recognize this as treatment is different than standard degenerative cleavage tears. Techniques are described in the next section followed by outcomes.

Saucerization

The goal of saucerization to preserve more meniscal width than previously thought: retaining 10 to 15 mm of tissue [27, 28••] as opposed to the classic guidelines of 6–8 mm [29]. Yamasaki et al. assessed 45 knees with DLM undergoing

Fig. 3 Arthroscopic images of a left knee demonstrating near complete coverage of the lateral plateau followed by saucerization revealing myxoid ID tissue (same knee as MRI images in Fig. 2)
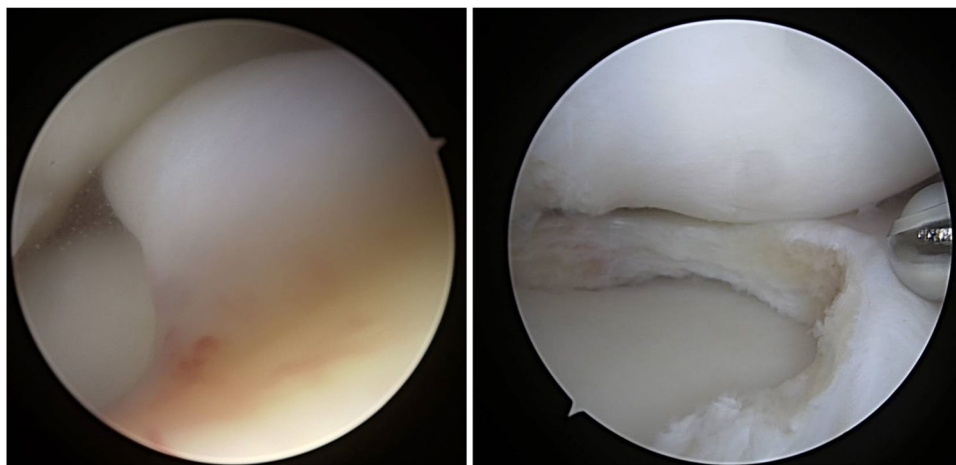
saucerization with repair as indicated and identified an inverse correlation between residual meniscal width and functional outcomes and joint preservation, with 5 mm of residual meniscal width being the threshold for radiographic degenerative changes at mean 40 months postoperatively [30••]. Additionally, several studies have shown that meniscal width decreases significantly in the first months to years postoperative from DLM surgery [31, 32]. Smaller residual meniscal width postoperatively has also been associated with extrusion of the lateral meniscus at 2 years [33]. A separate study reports meniscal width in non-discoid menisci to be 12–15 mm [28••]. These findings suggest that a larger meniscal width than previously thought should be maintained when saucerizing DLM.

Repair

The operating surgeon should be prepared to repair when operating on DLM. As discussed, ID will be unveiled as saucerization is performed and the DLM will often appear as a superior and inferior leaflet. Surgical options are to resect one or both leaflets, or to repair. This will depend on the tissue quality and volume as determined by the operating surgeon. Techniques for repair have been described that take into account the altered ultrastructure and biomechanics of the DLM [34, 35••].

Optimal technique comprises first arthroscopic assessment of the meniscus for tissue quality, thickness, and stability. Next, limited saucerization is performed leaving the aforementioned 10–15 mm of meniscal width. At this point, examination of the residual meniscal tissue will allow the surgeon to identify ID and intrasubstance tearing as well as any peripheral instability. Once the presence and extent of ID has been established, any loose or myxoid tissue is debrided and the leaflets are probed for repair potential. If a cleavage plane is present from either horizontal tear or compromised ID tissue, repair should be performed to bring the two leaflets together. A far medial accessory portal can be useful in accessing the anterior half of the meniscus as described by a senior author of this article [35••]. Following debridement of any myxoid tissue, trephination within the seam of the tear to promote capsular bleeding, and freshening of the tear edges with a rasp is performed ahead of repair. Nonabsorbable suture (0, 2–0, or small tape) is placed circumferentially around the meniscus in haybale fashion using an all-inside meniscal based suture passing device (Scorpion — Arthrex, Naples, FL; Novostitch — Smith & Nephew, Andover, MA), compressing the superior and inferior leaflets together. Repair sutures are placed 4–5 mm apart to maximize compressive forces. Figure 4 demonstrates an example of this repair technique.

All inside capsular based repair devices (ex. Fiberstitch — Arthrex, Naples, FL; Fast-Fix Smith & Nephew,
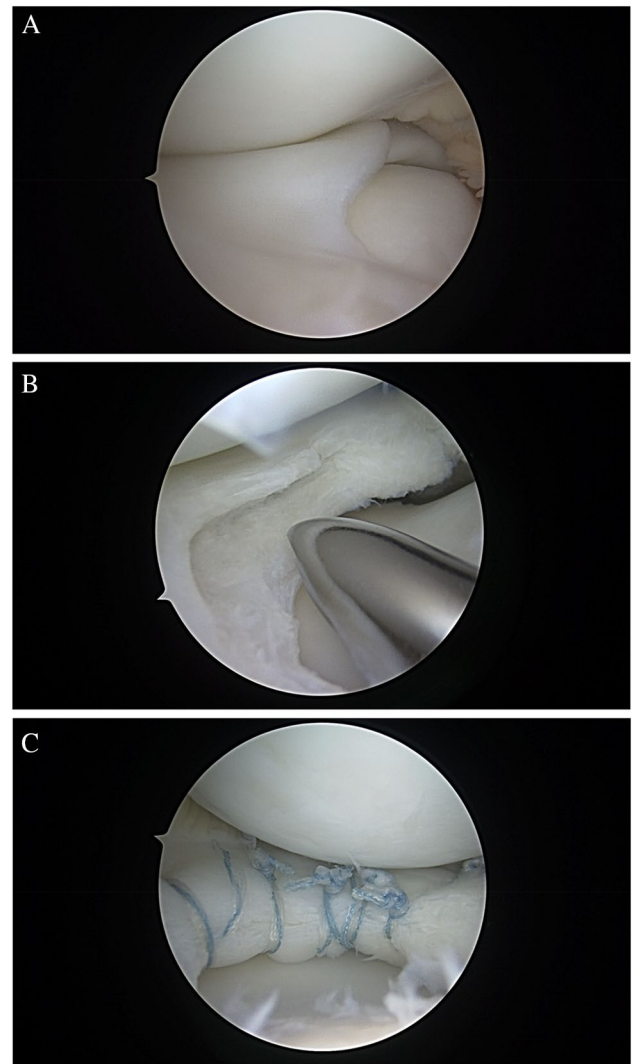
Fig. 4 **A**, **B**, **C**: Arthroscopic images of a right knee DLM saucerization and repair. Image **A**: discoid tissue without obvious external tearing. Image **B**: following saucerization with ID revealed, with similar appearance to horizontal cleavage tear. Image **C**: following all-inside haybale suture placement

Andover, MA) can also be used. If peripheral instability is present following intrasubstance repair as above, then meniscocapsular repair may be required as well, or alternatively capsular-based repair techniques can be utilized for intrasubstance repair (Fig. 5). This can be performed with all-inside meniscocapsular anchor implants, all inside meniscal based suture passing devices or inside-out/outside-in per surgeon preference. Lastly, biological augmentation commonly performed via marrow venting is recommended following meniscal repair to improve healing. This can be performed in the intercondylar notch or using the accessory far medial portal into the medial non-articular cortex of the medial femoral condyle. The authors' preferred technique involves marrow venting

Fig. 5 **A**–**D**: arthroscopic images of a right knee. (**A**) DLM with full coverage of the lateral tibial plateau. (**B**–**C**) ID revealed as saucerization is performed. (**D**) all-inside capsular-based anchors being placed with similar compression of leaflets to Fig. 4 images. The difference in this case is the repair technique with capsular-based repair stitches in this figure and all-meniscal suture without capsular inclusion in Fig. 4
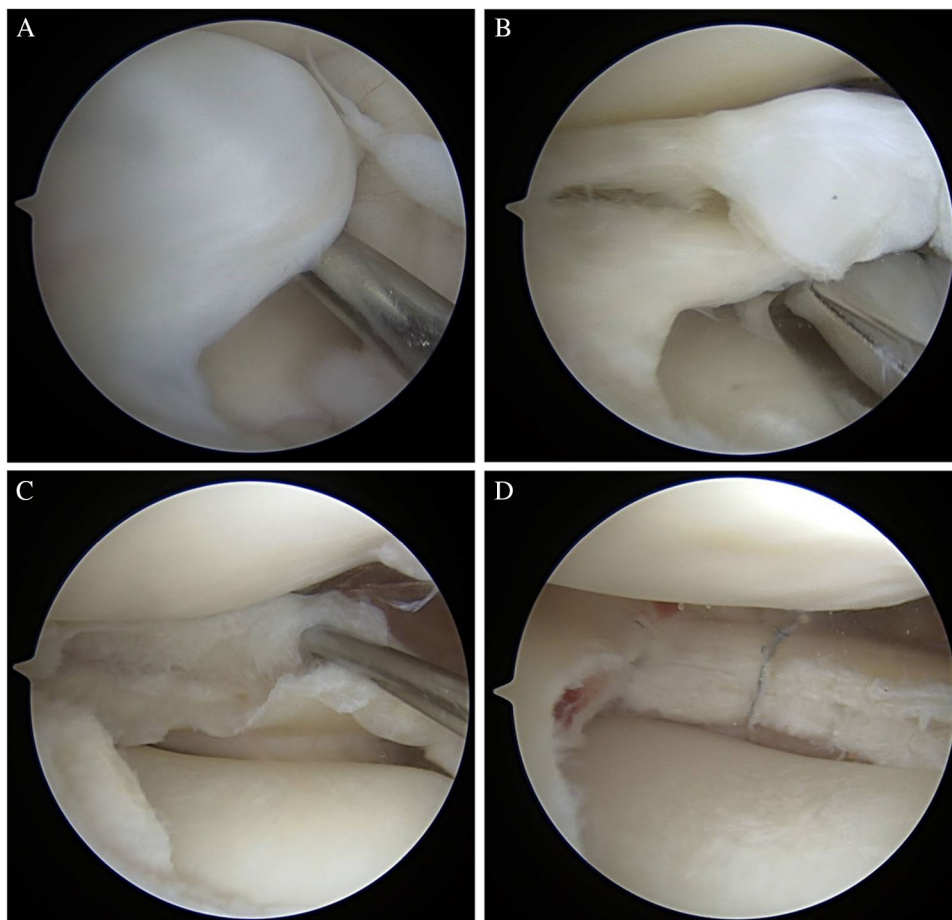
using a microfracture awl or motorized awl on the medial aspect of the medial femoral condyle using the far medial accessory portal created for repair. Utilizing these DLM-specific techniques will maximize residual tissue volume, quality, and stability.
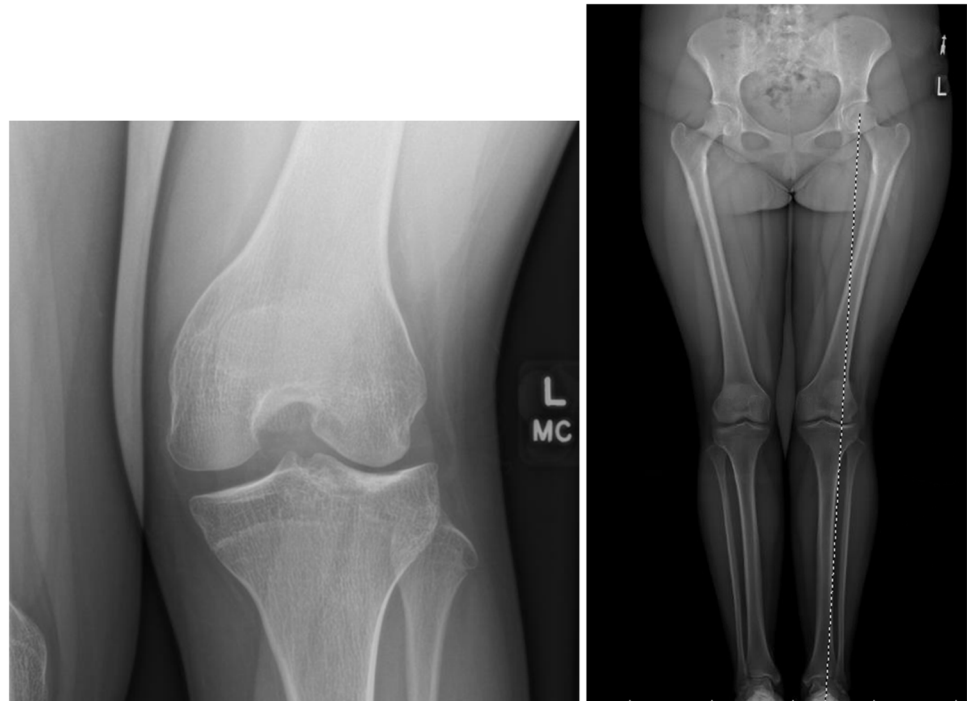
Outcomes

Degenerative changes have been widely described following surgical treatment of DLM [23, 25, 36••, 37] with progression to symptomatic lateral compartment osteoarthritis in 50% of knees 8 years following surgical treatment [36••]. Further, 59% of patients experienced retear by the same time point [36••]. Partial lateral meniscectomy or saucerization alters the limb axis, with slight progression in valgus alignment occurring after saucerization for DLM in patients with normal mechanical axes [38•]. In treating individuals with baseline valgus alignment, these changes must be taken into account when treating DLM. A large series of 419 knees undergoing surgery (saucerization +/− repair) for DLM revealed a 17% reoperation rate at median 20 months postoperative, with 94% of reoperations performed for retear [39].

Reviewing outcomes of repair, it is difficult to elucidate the durability of meniscal repair for DLM compared to saucerization alone, as repair is performed at the surgeon's discretion and is not always indicated. Studies comparing partial meniscectomy/saucerization with or without repair therefore yields similar outcomes between the groups [39–42].

Managing the long-term complications of chondral disease, meniscal deficiency, and possible valgus deformity requires thorough evaluation and discussion with the patient and their family. Multiple procedures are frequently required. Goals are to restore the knee joint as much as possible, which may require meniscal transplantation, cartilage preservation procedures, and/or osteotomy to correct alignment and offload the lateral compartment. Meniscal allograft transplantation (MAT) has been described in the setting of subtotal lateral meniscectomy for DLM [43–46].

While controversial, MAT as soon as meniscal deficiency is identified, even prior to symptoms, has been recommended [43] and is often the practice of a senior author on this paper (JLP). Early MAT is associated with superior outcomes [23] and is cost-effective to delay arthroplasty [47]. Improved pain and function have been widely

Fig. 6 AP and standing alignment radiographs of an adolescent patient s/p subtotal lateral meniscectomy for DLM, now with 6 degrees valgus deformity

described for MAT in the setting of failed arthroscopic treatment of DLM [48–52]. However, even with salvage procedures such as MAT, while improved compared to preoperative function, outcomes are still inferior when performed for DLM as compared to non-discoid lateral meniscus [49, 50]. It is theorized that the bony anatomy formed alongside DLM (condylar prominence and squaring) may contribute to these differences.

Osteotomy, typically at the distal femur, may also be required if progressive valgus deformity has developed and/or to offload the lateral compartment for any cartilage procedures. Limited long-term data has been described for both MAT and osteotomy, but studies assessing these procedures specifically following DLM meniscectomy show good clinical outcomes [53, 54]. The case in Fig. 6 demonstrates a 15-year-old patient status post subtotal lateral meniscectomy for DLM, now with 6 degrees valgus deformity and meniscal deficiency.

Treatment Algorithm

In brief, surgical treatment is recommended for symptomatic DLM as follows:

1. Intraoperatively, the surgeon should first perform limited saucerization with 10–15 mm residual width.
2. Next, one should assess ID and repair with haybale technique (can be all-meniscal based with suture passing device and knots, or capsular based with anchor-based suture implants, depending on peripheral stability).
3. Following intrasubstance repair, assess periphery and augment repair to capsule if needed.

Separately, in a patient presenting status post partial meniscectomy with ongoing symptoms, standard radiographs including standing alignment radiographs and MRI should be performed. All pathologies should be addressed which may include MAT, osteotomy, and cartilage transplantation. Diagnostic arthroscopy may be required first in order to assess meniscus and cartilage before definitive cartilage or meniscal transplantation.

Future Directions

Our understanding of DLM continues to advance and therefore so does our ability to optimize treatment. The order of pathology is still not fully understood in a "chicken or the egg" scenario: if the peripheral mobility is a result of the thickened tissue and increased shear stress on peripheral attachments, or if the peripheral deficiency is also congenital and increases tear risk in the DLM. Identifying stepwise progression of pathology may help elucidate early treatment options or potentially prophylactic interventions to avoid ongoing pain and frequent need for multiple surgeries. Future directions for studying DLM also include refining repair techniques to account for abnormal tissue. Further biologic

augmentation of repairs may offer some improved healing potential but has not been thoroughly studied.

Declarations

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