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Associated Abnormalities of Deltoid Ligament of the Ankle- A Review

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Abstract:

The deltoid ligament complex is an important structure for middle ankle stability and yet very few data are available. Many other structures are also involved in medial ankle stability, however, not all of them are involved in ankle injury. The injury pattern of the deltoid ligament is complicated, with the superficial ligament being most commonly affected site. Anatomically divided in two parts; the superficial and deep layer; the deltoid ligament complex has important functions in relations to the ankle joint. Ankle fractures account largely for injury of the ligament. Studying and understanding the anatomy and biomechanics of the deltoid ligament and its components is very helpful in regards of repair or the reconstruction in case of ligament injury or instability. Arthroscopy has the potential to assess for deltoid ligament damage, mainly the medial aspect. There is a currently no fixed guidelines for the management of acute deltoid ligament during fixation of ankle fracture. The traditional method of treating ankle fractures involving the fixation of the fibula and the use of syndesmotic screws is still being used for injury to the deltoid ligament. Controversy still exists concerning whether to opt for an operative approach of

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deltoid ligament injury associated with ankle fracture. With the emergence of better understandings of the anatomy of the deltoid ligament, further standardization of treatment and diagnosis protocol are required for deltoid associated injuries.

Key words: *Ligament Specimens, Associated Abnormalities,* surgical aspect, Arthroscopy

INTRODUCTION

The deltoid ligament complex is the primary structure responsible to stabilize the ankle against valgus impacts. It is grossly divided into two parts; the superficial and deep layer. The tibiospring, tibionavicular, tibiocalcaneal and the superficial posterior tibiotalar ligaments are the structures that made up the superficial deltoid ligament, with the anterior and posterior tibiotalar ligaments forming the deep deltoid ligament [1].

Campbell et al. after studying cadavers found that the tibionavicular, tibiospring and deep posterior tibiotalar ligaments were present in all of the specimens, but the other ligaments varied in appearance. They thus considered only the three ever-present ligaments to be the main structures of the deltoid ligament complex [2]. The deep deltoid ligament was found in prior studies to be the structure that provide the most stability to the ankle against a valgus force, with the superficial deltoid ligament providing only a little contribution to that aspect [3,4,5,].

Ligament Specimens

The three main functions of ligaments are: firstly providing mechanical passive stability to joints which help the joint through their normal range of motion under applied tensile or compressive force. Secondly provide the joint with viscoelasticity that protect the equilibrium of the joint

environment. The Viscoelasticity function is when constant load is apply to deform the ligament results in a decrease in that intra-ligamentous tension [6,7,8]; and also "creep" arises when the ligament is elongated due to a constant or periodic repetitive load. Thirdly they serve as a sensory organ where the ligaments monitor and distribute afferent kinesthetic and proprioceptive information [9,10,8]. The mechanoreceptors found in ligaments and joint capsule transmit the proprioceptive data, then react to changes in joint angle, joint velocity, mechanical distortion, and changes in intra-articular pressure to influence stability of the muscular joint [11,12,8]. The ligaments around the ankle joint can be divided into 4 regions: the distal tibiofibular syndesmosis, the lateral region, the deltoid ligament, and the sinus tarsi ligaments [13]. The distal tibiofibular syndesmosis is made of the anterior (ATiFL), posterior, transversal, and interosseous tibiofibular ligaments and the interosseous membrane [14].

The lateral region is composed of the calcaneofibular (CFL), anterior talofibular(ATFL), and posterior talofibular (PTFL) ligaments. The deltoid ligament is part of the medial complex. It can be divided into a superficial layer that is made up of the tibionavicular (TNL), tibiocalcaneal (TCL) and superficial tibiotalar (STTL) portions, and a deeper layer, consisting of the anterior (ATTL) and posterior (PTTL) tibiotalar portions [15]. The sinus tarsi is composed of the inferior extensor retinaculum which includes lateral (IERL), intermediate (IERI), and medial (IERM) roots; the talocalcaneal oblique ligament (TCOL); and the canalis tarsi ligament (CTL) [16]. The most common injury of the ankle joint is sprain [17].

Lateral ankle ligament sprains accounts to 85% of all ankle sprains while eversion sprains of the deltoid ligament accounts to 5% and syndesmosis sprains accounts to 10% of these injuries [18]. This statistic indicates that the different ligaments of the ankle work in different ways to stabilize the ankle. Ligaments adapt responsively to the forces impacted on

them and they configure their composition and mechanical properties accordingly [19].}The ATiFL being part of the distal tibiofibular syndesmosis was cut out [20,21]. The ATFL, PTFL, and CFL were removed from the lateral region [21]. The ATFL appeared as a single ligament in 7 cases and as a double ligament in 3 cases. The different portions of the deltoid ligament were defined according to the description of Pankovich and Shiravam [15]. The structures of the superficial layer (TNL, TCL, STTL) and the structures of the deep layer (ATTL and PTTL) of the deltoid were resected from the medial region. The description of Schmidt was used to define the ligaments of the sinus tarsi [16]. The IERM, IERI, and IERL roots of the inferior extensor retinaculum, the TCOL, and the CTL were harvested in the sinus tarsi. The CTL in the sinus tarsi presented as 2 portions in 8 cases and as1 portion in 2 cases in the sulcus tali.[22].

Associated Abnormalities

The lack of high-level evidence emboldens the difficulty on the general consensus on the diagnosis and management of syndesmotic injuries. This article reviewed one of the most common athletic injuries, isolated syndesmotic injuries without fracture. One of the most frequently affected joints in the athletic community is the ankle [23] Inversion mechanisms with a sprain or disruption of the lateral ligament complex make up the majority of these injuries [24,25] Prolonged pain, disability and an unforeseeable period of time away from sports are common occurrences of syndesmotic injuries [26]. The most prognosticative factor of chronic ankle dysfunction at 6 months post-injury was involvement of syndesmosis according to Gerber et al. [27]. Patients with isolated lateral ligament sprains took about half of the time to make a comeback to athletic activities as compared to those with syndesmosis involvement as shown by Wright et al. [28]. The occurrence of these injuries could be either in isolation or together with other

ligamentous, bony or cartilaginous injuries around the ankle area [26]. Osteoarthritis could be the result of missed and/or chronically unstable injuries [29].From his cadaveric study, Michelsen found that by applying a laterally directed force to the transection of superficial deltoid ligament alone did not result in a large gap of the medial clear space (MCS) [3].

Walling and Sanders suggested that with only injuries to ligaments of the deltoid complex resulted from cases of isolated fracture of the lateral malleolar, there is no need of further repair after management with lateral fixation [30]. However it was found that in some patients with isolated lateral fractures after treatment with fixation experienced valgus instability. The preoperative magnetic resonance imaging (MRI) of these patients showed that the disruption of the deltoid ligament complex were of varying degrees. This led to a hypothesis that damage to the deltoid ligament in patients with lateral malleolus fractures made them susceptible to instability despite having received fixation. The goal of this study was to evaluate the role of the anterior deltoid ligament plays in ankle stability to resist a valgus load in patients with isolated lateral malleolus fractures [31].

There is a high likelihood that this range is an underestimation as many cases may be frequently missed or undertreated. A prospective study of 639 ankle sprains was performed by Fallat et al., during which an incidence of 5% was solely obtained from diagnosis by clinical examination [32] Boytim et al. found, a contrario, an incidence of 18% from diagnosis through clinical examination and plain radiographs[33]. Higher incidences are obtained from certain high-impact sport disciplines such as soccer, ice hockey and skiing [34, 35, 28].

Over a period of three years, 60 collegiate athletes with syndesmotic injuries were identified by Nussbaum et al. [36] in a single institution during which a higher incidence was indicated. Furthermore, a prospective study of an athlete

population by Waterman et al. [37] obtained an incidence of 6.7%. There is a clear lack of consistency in diagnosing the injury from these studies. It is very hard to use data from prior studies to find the true cause of this injury as different criteria have been used in different papers. In addition, some have used MRI or other advance imaging techniques rather than just relying on plain radiographs. As these injuries are becoming more known as well as emphasis is being made on its early diagnosis and together with MRI being more accessible may increase the chance of identifying the incidence[38].

Arthroscopy:-

Hintermann et al. [39,40,41,42] proposed that using arthroscopy is very helpful in evaluating medial instability. In a study carried out in 148 patients, it was found that arthroscopy revealed a greater number of patients (36.5%) were affected with medial instability than what was presumed clinically (25.7%).[39] In another study among 110 patients carried out by Hintermann and Shaffer, it was found that only five ankles showed medial instability on clinical exam as compared to arthroscopy which showed 23 [41].

From these studies, it is suggested that medial instability might be present in more patients than previously thought as it might have eclipsed clinical diagnosis. [40]Hintermann et al., following a study of acute traumas also found that arthroscopy could only detect 84.4% of deltoid ligaments just after trauma. And also, Schuberth et al [43]. reported that arthroscopy was unable to reveal the superficial structures of the deltoid ligament following lateral malleolar fractures [44]. From both of these statements, it is found how difficult it is to evaluate the anatomy of the deltoid in different circumstances.

In athletic patients in particular, it is found that anteromedial impingement is of common occurrence. Also damage to the deltoid ligament might be present in those

cases[44]. Murawski and Kennedy [45] after following 41 patients for a minimum duration of 2 years observed that there might be infolding of the deltoid into the joint in dorsiflexion that can potentially cause impingement. The impingements in those cases were removed by arthroscopy without any alteration to the ligament. Mosier-La Clair et al. [46] followed a small group of 11 patients having impingement to the anterior tibiotalar fascicle of the deltoid for a period averaging to 4 years and the report following resection by arthroscopy was positive.

Arthroscopy of the hindfoot enables access to the deltoid ligament in cases of posteromedial ankle pain. In those cases the pain may arise as a result of calcifications, avulsion and/or ossicles in the deep deltoid ligament. Cedell [47] was the first to give descriptions about avulsed ligament of the deep layer of deltoid. He reported that hyper dorsiflexion and eversion trauma of the ankle were the causes of the avulsion. Minimally invasive surgery (tendoscopy) which, is used by the senior author JGK is gaining more and more popularity. During this procedure, the superficial deltoid can be seen and also at the same time laxity can be assessed by externally rotating the ankle. As of now arthroscopy is used only as a diagnostic tool for assessing deltoid damage with no arthroscopic treatment method yet available[44].

SURGICAL ASPECT

It has been noticed through experience after treating many athletes having ankle fractures that the superficial deltoid complex had often undergone complete avulsion off the proximal part of the of the medial malleolus. Many times due to complete medial instability together with infolding of the deltoid complex prevent the mortise from being anatomically reduced with the medial clear space continuously increasing. [48]. It has been observed that this particular injury pattern is

mostly seen in injuries to football linemen. A common case is that of high impact injuries when players fall directly on the ankle of another player [48].

This can cause fracture of the fibula, syndesmotic damage and avulsion of the deltoid complex. It is thought that by retracting the avulsed deltoid complex through a non-anatomic position healing might cause chronic gutter pain, instability of the ankle. Also in the long run, there might be functional loss and the possibility of potentially developing early arthritis. The objectives of these descriptive studies were to assess the outcomes and complications in NFL players following repair to their acutely avulsed deltoid complex during ankle fracture fixation [48].

There is a controversy in the management of acute deltoid ligament during fixation of ankle fracture as there is no fixed guideline about the best or most appropriate method of treatment or surgical repair[49,50,51,52,53,54,55,56,57]. There is an indirect way of treating the deltoid ligament through the traditional method of treating ankle fractures including injury to the deltoid ligament. It involves the fixation of the fibula and the use of syndesmotic screws to stabilize the residual mortise[58,59,55,57]. Previously, the results obtained could not distinguish between subjective or objective outcomes with repairing deltoid ligament through the fixation management of the ankle fracture or with non-surgical treatment of the deltoid[60,55,57]. During these studies, fracture displacement and the free medial space measurement were obtained with intraoperative radiographs. However intraoperative radiograph were unable to assess the instability to the medial part during stress examinations or direct visualization. It is reported through examination by arthroscopy that injury to the deltoid ligament occurs in about 40% of ankle fractures[61].

A surgical study consisting 54 cases about deltoid ligament injuries were reviewed and it was found that 20 of these cases were due to tears in the flexor retinaculum (37.0%).

6 out of 54 were associated to tears in the spring ligament (11.1%). 1 patient who received surgery due to ankle pain had a tear of the flexor retinaculum but no deltoid tear[62]. There were 52 cases that received surgery for lateral instability and they were associated with injuries of the deltoid ligament as well as injuries to the lateral collateral ligament. Out of this 52, 35 patients (67.3%) underwent surgery due to tears in the deltoid ligament. Among these 35 cases, 18 involved both the superficial and deltoid ligaments, 15 involved only the superficial deltoid ligament and 2 involved only the deep deltoid ligament. These findings corroborate with prior reports and suggest that the deltoid ligament injuries are of high prevalence in patients with lateral instability[63,64].

Another surgical study involving 24 cases on syndesmosis injuries were recorded. Among these, the injuries of 7 ankles were of both the anterior and posterior inferior tibiofibular ligaments; out of which 5 were with injuries to both superficial and deep deltoid ligaments and 2 with a superficial deltoid injury only but no record for the deep deltoid[62]. Another 13 patients had an injury to the posterior inferior tibiofibular ligament only; out of which 7 suffered injuries to the superficial and deep deltoid ligaments, three suffered superficial deltoid injury only, 2 with no deltoid ligament injury, and one with a superficial deltoid injury recorded but no record for the deep deltoid. The remaining 4 patients had an injury to the anterior inferior tibiofibular ligament only; out of which one had injuries to the deep and superficial deltoid ligaments, 2 had injury to the superficial deltoid only, and 1 had injury to the superficial deltoid but no record for the deep deltoid. Although edema is a helpful indication of acute injury, it was not included as a diagnostic criterion in this study as most cases involved in these series were due to chronic injuries. Edema has low specificity for cases of chronic instability[62]

CONCLUSION

Ankle ligament injuries including the deltoid ligament complex are very common in sports and recreational activities. The injury pattern of the deltoid ligament is complicated and there us yet to be a universal protocol concerning the diagnosis and treatment approach for deltoid ligament injury associated with ankle fracture. With better understandings of the anatomy of the deltoid ligament, standardization of treatment and diagnosis protocol are required for deltoid associated injuries.

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