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Treatment of Pediatric Bone Mallet Finger: The Current State of the Art and a Proposal of Algorithm Treatment

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ABSTRACT

Introduction: Bone Mallet finger is a common hand fracture and refers to a lesion of the terminal extensor complex with bone avulsion. In literature, so far, there is a lack of studies that identify the treatment for mallet finger in the pediatric population. For this reason, the purpose of this research is to clarify the correct treatment and to propose a therapeutic algorithm.

Materials and Methods: Thanks to the research database PubMed and Cochrane library we have selected all the studies regarding the mallet finger treatment in the pediatric population. Due to the shortage of specific studies, we have decided to include every result that satisfies our field of research.

Results: In literature there is no clear indication of the treatment of pediatric mallet finger. The treatment ranges from non-operative to surgical treatment. The conservative treatment is based on the immobilization of the distal interphalangeal joint for 6 weeks. By contrast, there are several surgical techniques that can be performed, including percutaneous fixation with K- wires (Ishiguro technique) and open reduction;

Discussion: We believe, that the different involvement of the articular surface of the distal interphalangeal joint plays a crucial role in the choice of treatment. According to the current studies, we have proposed an algorithm for treatment from x-ray assessment and classification system through conservative and operative intervention.

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Introduction

Mallet finger refers to an injury of the terminal extensor tendon, resulting in a loss of active extension at the distal interphalangeal (DIP) joint [1].

It most commonly occurs during sports activities, particularly following a direct trauma that forces a flexion or hyperextension of the extended distal phalanx. This causes a disruption of the extensor tendon, either in isolation or in combination with an avulsion fracture of the distal phalanx (commonly referred to as a "bony mallet finger") [1,2]. Functionally, this injury leads to an extension lag at the DIP joint, which, if left untreated, can progress to osteoarthritis or a characteristic swan-neck deformity at the proximal interphalangeal (PIP) joint [3]. Pediatric mallet finger should be considered distinct from adult cases for several reasons. First, the presence of the physis in the proximal third of the distal phalanx, which closes between ages 13 to 16, plays a critical role [4,5]. Anatomically, this area is a point of weakness due to the extensor tendon insertion, making it more susceptible to avulsion fractures, which are more common than soft tissue injuries in this population [6].

Additionally, patient compliance significantly affects the outcome of conservative treatment. Achieving strict adherence to the long period of immobilization can be challenging in pediatric patients [7]. A meta-analysis of Hangoll et al. demonstrates the importance of strict adherence when a conservative treatment is indicated [8].

Mallet finger injuries are commonly classified according to the Doyle classification, which divides them into four types: closed injury (with or without avulsion fracture) (type 1), open injury with tendon laceration (type 2), open injury with tendon and soft tissue loss (type 3), and mallet fracture (type 4) . Type 4 is further subdivided into three categories: transphyseal fractures in children (type A), hyperflexion injuries involving 20% to 50% of the articular surface (type B), and hyperextension injuries involving more than 50% of the articular surface (type C). Another commonly used system, described by Wehbe and Schneider, categorizes injuries based on severity: no DIP joint subluxation (type 1), DIP joint subluxation (type 2), and physeal or epiphyseal injuries (type 3). Each type is further subdivided based on the percentage of the articular surface involved: less than 30% (subtype A), 30% to 60% (subtype B), and more than 60% (subtype C) [9].

Another system of classification, described by Wehbe and Schneider is also commonly used and it is based on the severity of the injuries: no distal interphalangeal joint subluxation (type 1), distal interphalangeal joint subluxation (type 2), and physeal or epiphyseal injuries (type3), while all injuries are further subdivided based on the involvement of articular surface: less than 30% (subtype A), 30% to 60% (subtype B), and more than 60% (subtype C) [10].

All these systems of classification have played an important role in the choice of treatment [9,10].

A recent study of Yang et al. has proposed a new model of classification based on the involvement of the surgical surface, the thickness of the fracture (thickness of the middle part of the fracture fragments in sagittal plane) and the time elapsed between the injury and the treatment [11].

In type I mallet fractures, the fracture involved <20% of the joint surface, the thickness of the fracture was < or = 3 mm, and there was no dislocation of the IFD joint. In type II mallet fractures, the fracture involved 20% to 50% of the joint surface and the fracture thickness was < or = 3 mm. Type II was further divided into two sub-types: in Type IIa fractures, the untreated time after injury was < or = 2 weeks; and in Typ IIb fractures, the untreated time after injury was > or = 2 weeks and the fracture was usually complicated by palmar subluxation of the IFD joint. In type III mallet fractures, the fractures involved > 50% of the joint surface, and the thickness of the fracture was > 3 mm; most of these fractures were also accompanied by dislocation of the IFD joint [11].

The study of Kim et al and Moradi et al. have demonstrated that the involvement of the fracture in the surface of the distal phalanx base is closely associated with a palmar subluxation of the IFD joint [11-13].

The biomechanical studies of Husain et al. and Kim et al. revealed that subluxation of the IFD joint occurred when the fracture involved half of the joint surface; while the study of Moradi et al. revealed that IFD joint dislocation occurred when the fracture involved more than 39% of the joint surface [12-14].

The lateral collateral ligament is the main factor involved in maintaining the stability of the IFD joint, and a mallet fracture involves the lateral collateral ligament to varying degrees. Yang et al. have measured the insertion of the collateral ligament on the base of distal phalanx, and have found that the width of the terminal part was < or = 3 mm; i.e. that a fracture thickness > 3 mm might affect the stability of the joint [11].

The study of Yang showed that the IFD joint was stable when the range of rupture of the lateral collateral ligament was <= 25%, while rupture of >= 50% significantly affected the stability of the IFD joint.

It's also important to point out how much time passes between the injury and the beginning of the treatment, because that influences the type of treatment itself. Mallet injuries seen within 4 weeks from the injury are defined as acute mallet finger, while those treated after 4 weeks from the traumatic event are identified as chronic mallet finger [15].

Materials and Methods

Thanks to the database Pubmed and Cochrane library, we have selected all the studies regarding "pediatric mallet finger". Due to the lack of studies in Literature, all the studies were included in our research. The authors have adhered to the the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

Results

Currently, there is a notable gap in the literature regarding clear treatment indications for mallet finger, particularly within the pediatric population. Several treatment options are proposed for acute mallet finger, with conservative management being the most common. This approach involves immobilizing the DIP joint with an orthosis in full extension for a minimum of 6 weeks, followed by an additional 2 weeks of nighttime immobilization . According to the study by Lin et al. this method of immobilization is a valid option for treating the majority of pediatric mallet finger cases.

Various types of orthoses can be used for mallet finger treatment, including Stack orthoses, modified aluminum orthoses, custom-made orthoses, casts, and buddy taping. Lin et al. compared the effectiveness of Stack orthoses, modified aluminum orthoses, and custom orthoses created by occupational therapists, finding no evidence of superiority or differences in complications among these options. Similar outcomes have been reported in studies involving the adult population, indicating that no particular orthosis type is significantly better than others [16,17].

In this context, patient compliance is crucial, as failure to strictly adhere to the prescribed treatment can lead to complications such as an extension lag, resulting in functional limitations of the DIP joint [6-8].

The literature describes several surgical techniques for treating mallet finger in the adult population, including closed reduction with K-wire fixation, tenodermodesis, open reduction with internal fixation, and tension band wiring . Lucchina et al. conducted the only study that compares the outcomes of three different surgical techniques: the Ishiguro technique, K-wire as a joystick, and interfragmentary miniscrew for open reduction and internal fixation. Their study found no significant differences in overall outcomes among the three techniques, although post-operative complications were more frequently reported following the mini- open technique.

When focusing exclusively on the pediatric population, the literature highlights surgical techniques such as K-wire fixation (Ishiguro method) and open reduction with K-wire fixation. However, there is no definitive evidence in the literature regarding the indications for surgical treatment or which of the aforementioned techniques should be preferred [7,18,19].

For someone, surgical intervention is recommended for unstable lesions that have an avulsed fragment that involved >50% of the articular surface of the base of the distal phalanx and/or the presence of the volar subluxation of the IFD joint [18,19].

A study of Chen et al, demonstrates that all mallet fractures involving at least one-third of the articular surface with volar subluxation, appear to be amenable for surgical fixation with closed reduction and fixation with K-wire, because those features identified an unstable fracture, that, if left untreated, could create post-traumatic complications [7].

The majority of the studies found in literature reported that closed reduction has less post- operative complications compared to the open reduction [7,20].

On the other hand, for the chronic mallet finger, without volar dislocation, Ota et al. Proposed a treatment based on Lipus therapy (low-intensity pulsed ultrasound system), with better results, including functional outcome, compared to patients treated with K-wire fixation [20].

Surgical treatment with open reduction should be considered for chronic mallet finger, particularly when the development of fibrous tissue between the fracture and the distal phalanx may complicate closed reduction [7].

The orif technique is often associated with post-operative complications, such as soft tissue damages, skin necrosis or infections [21-23]. According to various authors, due to the many post-operative complications, open reduction should be used in selected cases, where closed reduction has failed [21,22].

This study has several limitations. Firstly, due to the scarcity of research concerning the pediatric population, we did not evaluate the level of evidence or the quality of the selected studies. Additionally, there is a lack of consistency in the classification systems used in the studies reviewed, as well as in the indications for treatment and the techniques employed [23-26].

Discussion

There are currently no clear guidelines regarding the treatment of mallet finger in the pediatric population. In this analysis, we aimed to clarify the management of mallet finger using a treatment algorithm (Figure 1).

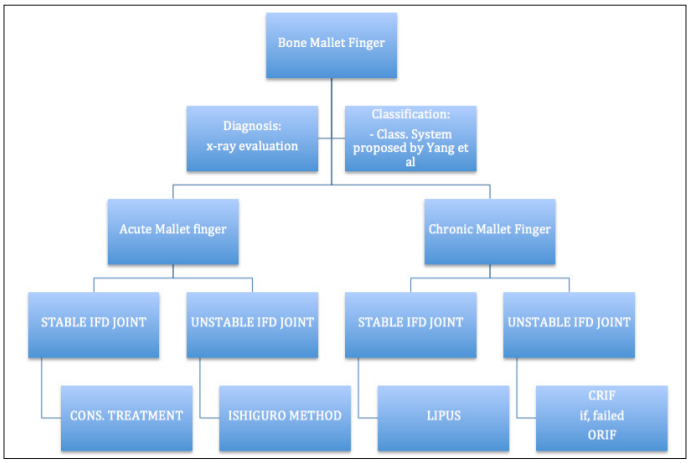

Figure 1: Proposal of Algorithm for the Treatment of Pediatric Bone Mallet Finger

Based on the study by Yang, we believe that the stability of the DIP joint is crucial in determining the appropriate treatment approach. The new classification model proposed by Yang et al. provides physicians with a comprehensive understanding of the injury's size and the stability of the DIP joint.

The first step is to assess the extent of the fracture using X-rays in both lateral and anterior- posterior views, determining whether it is an acute mallet finger (≤ 4 weeks) or a chronic one (≥ 4 weeks). Following this, the fracture is classified according to Yang et al.'s system.

If an acute mallet finger is diagnosed and the DIP joint is stable, the treatment of choice consists of immobilization with an orthosis for at least 6 weeks, followed by an additional 2 weeks of nighttime immobilization. It is essential to monitor patient compliance during this period, as non-adherence to the prescribed treatment can lead to extension lag and functional limitations of the DIP joint.

In cases where the DIP joint is unstable—specifically when the fracture thickness is ≥ 3 mm (Type IIb and Type III)—closed reduction with K-wire fixation has shown excellent outcomes and a lower complication rate compared to open techniques.

For chronic mallet finger, treatment focuses on Low-Intensity Pulsed Ultrasound (LIPUS) therapy when the joint is stable and surgical intervention with closed or open reduction and internal fixation when the joint is unstable. Open reduction is reserved for select cases of chronic mallet finger, particularly when significant fibrotic reaction has led to failed closed reduction.

However, further studies are necessary to validate the proposed algorithm for the treatment of pediatric mallet finger.

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