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Delta Wiring Technique to Treat Bony Mallet Fracture

Technique Description and Case Series

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Abstract:- Delta wiring has become a widespread technique for the treatment of bony mallet fracture. This technique enables fragment compression and immediate DIP joint active movement. The Delta wiring has become an alternative for the extension bock technique. We intend to describe the technique and results of Delta wiring for the surgical treatment of bony mallet injury. The aim of this study was to describe the Delta wire and provide a clinical and radio- logical evidence in the treatment of mallet fractures. The hypothesis of this study was that Delta wiring technique would obtain similar clinical and functional results to those of traditional extension block in the surgical treatment of mallet fractures, and that Delta wire could be a safe, viable treatment choice as an alternative to Extension block technique.

- ***Methods:***

Eighteen patients submitted to Delta wiring for the treatment of mallet fracture were included and assessed in this study, during the period of January 2017 to May 2020 with a complete assessment in minimum follow-up of 6months. The technique was indicated for patients with acute mallet fracture, with intact overlying skin. Patients in pediatric age group, open fracture or ligamentous mallet were excluded.

- ***Results:***

We demonstrated good outcomes in regard to pain, range of motion, and union time.

- ***Conclusion:***

Delta frame wiring is a useful and safe technique. It is a less invasive procedure that carries few complications and is a good alternative to the extension block technique.

Keywords:- *Mallet fracture, Delta wiring , Frame, Extension block.*

I. INTRODUCTION

A mallet fracture is an intra-articular avulsion fracture of the distal phalanx. It is usually caused by a hard blow to the fingertip, causing sudden flexion[1,2], resulting in a tendon tear or fracture of the distal phalanx. This mechanism is common in athletes and is often described as finger pinching. A classic, often-seen example is a basketball player who catches the ball with his middle finger. Another less common cause of mallet finger injury is hyperextension injury with fracture of the dorsal lip of the distal phalanx.[3]

Splinting is effective. However, there are many conditions where surgery is indicated. These include open injuries and injuries with large dorsal bony avulsion fragments associated with palmar subluxation of the distal phalanx.[4] Fracture fragments more than 30% of the joint surface and joint subluxation are associated with permanent deformity. Fractures involving 30 to 50 percent of the distal interphalangeal joint surface has been described as potentially unstable.[5,6]

Reduction of the avulsion fragment can be achieved by closed or open means[7]. This will depend on the complexity of the fracture, patient characteristics, and surgeon preference. Various surgical fixation techniques have been described. Closed reduction can be performed by fixing the fragment with two Kirschner wires to create an extension block[8, 9]. This can also be done with compression fixing pins. Open reduction and internal fixation could be performed using Kirschner wiring, small screws, and hook plate. Most of the fixation methods require an axial Kirschner wire across the distal interphalangeal joint for protection of the fixation. One of the postoperative problems related to the fixation of fracture or protection of fixation by axial Kirschner wire across the distal interphalangeal joint is stiffness of the joint[10, 11]. The delta frame techniques do not require the protection of fixation by trans-articular axial Kirschner wire[12]. It allows free and full active motion of the distal interphalangeal joint immediately after operation. In this study we used delta wire technique to treat mallet fracture in eighteen patients.

II. METHODS

We included patients with a mallet fracture involving more than one-third of the articular surface of the distal phalanx, with or without subluxation, during January 2017 to May 2020. The mallet fracture was diagnosed by means of physical examination and further assessed by imaging (AP and lateral views) *"Fig 1"*, we included only recent and closed injuries.

Patients with ligamentous injury and those on postoperative follow-up less than six months were not included.

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After the procedure, patients were seen on a weekly basis during the first month, and then every 60 days until six months postoperatively. The retrospective review assessed clinical outcomes and possible complications due to surgery. The analysis of results comprised filling a questionnaire and a physical examination directly performed by one of the authors. Regarding the procedure, the surgical duration, type of anesthesia and postoperative range of movement of distal interphalangeal joint (DIP) were all considered. Results at the final evaluation included a subjective assessment, DIP range of motion, and presence of possible complications such as non-united, infection, stiffness, and implant failure. We also questioned the time to return to work (or to normal activities, in case of unemployed patients). *"Table 1"*. Results were rated as excellent, good, fair, and poor according to the Crawford criteria.

Fig 1:- Lateral view of right ring finger

III. SURGICAL TECHNIQUE

The procedure is carried on with local anesthesia and without tourniquet. We employed supine position and hand extended on hand table. An eighteen gauge cannula used for per cutaneous reduction. Lateral X-ray confirms proper reduction*" Fig 2"*. A Kirschner wire 0.8mm inserted dorsally through the bony fragment and came out from the skin on the palmar site *"Fig 3"*. A hook had been made in the dorsal end of Kirschner wire then the wire pulled from palmar side*" Fig 4".* The wire cut leaving 2cm length and another hook made. Another Kirschner wire 1mm inserted from fingertip along the long axis of the distal phalanx intramedullary without penetrating the DIP joint *"Fig 5"*. The wire cut and bended to form another hook. Both hooks connected to form a tension band which act to apply compression on the fracture site *"Fig 6"*. Dressing applied over the wires and the final fixation confirmed under fluoroscopy in AP and Lateral positions "*Fig 7, 8"*.

All patients were discharged on the same day of the surgery. A one week follow up appointment with x-rays on arrival booked for all patients, then two weeks follow up appointment till full union. Active range of motion exercises began immediately after surgery. Complications and bone union were assessed with clinical examinations and radiographs. Crawford's criteria has been used to evaluate the functional outcomes.

Fig 2:- Fracture reduction

Fig 3:- A Kirschner wire inserted through the fragment

Fig 4:- The wire pulled from palmar side

Fig 5:- Intra medullary wire

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Fig 6:- Hooks connected together


Fig 7:- A dressing applied over the wires

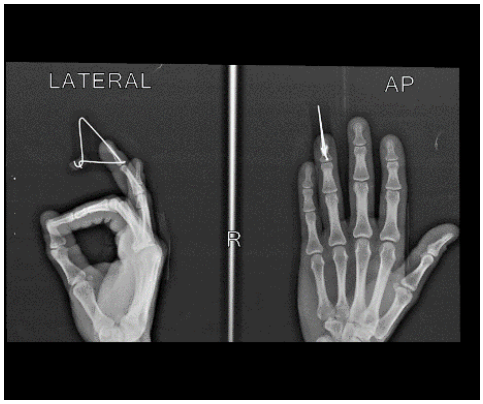

Fig 8:- Final radiograph

IV. RESULTS

Eighteen patients (Twelve Males and six females) with the mean age of 31.2 were treated with Delta wirring technique, the mean follow up period is six months. Bone union was achieved in six weeks in eleven patients, seven weeks in seven patients (mean 6.3). At the final follow up, nine patients are free of pain. However, two patients scored four in VAS. The remaining seven patients ranged from one to two. The DIP active flexion degree mean was 72.1 , and average extension lag of 2.7 . Regarding Crawford criteria ten patients had an exellent result, and six patients had a good result. However, two patients had fair results. No poor results observed.

V. COMPLICATIONS

There were no complications, such as comminution of the fracture fragment, nail deformity, volar subluxation, or dislocation or DIP joint osteoarthritis.

VI. DISCUSSION

Mallet fracture is one of the commonest hand injuries. Although conservative treatment has a role, many cases warrant surgery. Different surgical techniques have been proposed, and there is much controversy that which is the best technique. Extension block technique used frequently to treat mallet fractures. However, it do pose a high risk of DIP chondral injury and arthritis due to transfixing wire. Miranda et al used a blunt needle as a joystick to reduce the bony fragment of a stab incision. After reduction was achieved, a dorsal splint was applied holding the DIP joint in 15 to 30 degree extension. They achieved and maintained satisfactory reduction. However, patients who have rotational deformity may benefit from direct reduction techniques and more rigid fixation.

Open reduction to restore the congruity of the articular surface is indicated in old fractures more than five weeks.

The delta wire technique has been developed to reduce the risk of iatrogenic chondral injury and allows immediate post-operative active range of movement of DIP joint. In addition to allowing early mobilization, more importantly, this technique provides a compression effect in the fracture line when the DIPJ is brought to a flexion position by means of the K-wires tied in a hook shape. Our results with the delta wiring have demonstrated that it is a safe technique, with low rate of complications, and our sample did not present any case of poor outcome. It too has the advantage of reduced postoperative pain, and rapid return to work.

VII. CONCLUSION

Delta wire technique has good surgical outcome in terms of reducing pain and DIP active flexion, it applies direct compression on the fracture fragment preventing displacement and aids bone union. Also, it prevents iatrogenic chondral damage. The delta wire technique could be a good alternative to extension block technique in the treatment of mallet fractures. Further studies can be crucial to evaluate the efficacy of this approach with fracture fragments that involve less than one-third of the articular surface. The follow-up period is need to be longer to observe long-term adverse effects.

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Patient No	Age	Sex	Follow up Period (months)	Union time (weeks)	Time to return to work	VAS score at last follow up	DIP Flexion at last followup	DIP Extension lag at last follow up	Crawford Criteria
1	23	M	6	6	7	0	75	0	Excellent
2	46	M	6	6	7	0	73	7	Good
3	43	M	6	7	9	2	75	0	Excellent
4	22	F	7	6	8	4	73	10	Fair
5	24	M	6	7	8	0	70	7	Good
6	27	M	6	6	7	1	70	5	Good
7	40	M	6	7	8	0	73	0	Exellent
8	43	F	6	6	7	0	70	0	Exellent
9	33	F	6	7	8	2	70	5	Good
10	32	M	7	6	7	4	65	5	Fair
11	24	M	6	6	7	2	70	0	Exellent
12	21	M	6	7	8	0	75	0	Exellent
13	28	F	6	6	7	1	75	0	Exellent
14	33	F	6	7	8	2	70	0	Exellent
15	37	M	6	6	7	0	73	7	Good
16	28	M	7	6	7	2	72	0	Exellent
17	34	M	6	7	8	0	75	0	Exellent
18	25	F	6	6	7	0	75	3	Good

Table 1:- Patient's Characteristics

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