Section A -Research paper

Complication Of Non_ Thumb Metacarpal Fracture

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Abstract:

Metacarpal fractures comprise between 18–44 % of all hand fractures. Non-thumb metacarpals account for around 88 % of all metacarpal fractures, with the fifth finger most commonly involved. The majority of metacarpal fractures are isolated injuries, which are simple, closed, and stable. While many metacarpal fractures do well without surgery, there is a paucity of literature and persistent controversy to guide the treating physician on the best treatment algorithm.

Keywords: Non thumb metacarpal fractures, Function outcome, Flexor tendon injury.

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Introduction:

Hand injuries constitute a major proportion of trauma emergencies in developing countries on average, hand injuries count for 14% to 30% of all treated patients in emergency care. Tendon lesions are in 2nd position (29%), whereas fractures are 1st (42%) and skin lesions 3rd of all patients treated for **(Fig.1)** ***[1].***

Fig. (1): Compound fracture of the first metacarpal with volar dislocation of second, third and fourth carpometacarpal joint **[2].**

Classification of Non-Thumb Metacarpal Fractures : -

Metacarpal fractures can be divided according to the site of fracture to head, neck, shaft, and base fractures. They are further classified according to the fracture line into four types: transverse, oblique, spiral, and comminuted. each type can be intra-articular or extra-articular. They present its characteristic deformities that may lead to complications if unrecognized or improperly treated ***[3].***

A. Metacarpal Head Fractures:

Fractures of the metacarpal heads are relatively uncommon and usually result from a direct blow, crush injury, or

projectile. During an altercation, a metacarpal head fracture may be sustained when the patient strikes someone or something with a closed fist. The second metacarpal head (ray of index finger) is most involved, and the first metacarpal head (ray of thumb) is rarely fractured. In some patients, rupture of the collateral ligaments through a torsional, valgus, or varus stress can result in avulsion fractures at the metacarpal head [4].

Head fractures have been classified into several categories **(Table.1)** Comminuted fractures occurrs most. Half of the comminuted fractures had loss of more than 45 degrees of flexion at the metacarpophalangeal (MP)joint. Intra-articular fractures of the metacarpal head can also occur after complex dorsal MCP dislocation **[5].**

Table (1): Types of Metacarpal Head Fractures [6].

- **Epiphyseal (all nondisplaced salter-harris type).**
- **Ligamentous avulsions.**
- **Osteochondral slices.**
- **Three -part fractures occurring in different planes (sagittal, coronal, axial).**
- **Comminuted fractures.**
- **Boxers fractures with extension into joint.**
- **fractures with substance loss**

Metacarpal neck fractures (Boxer's fractures) are common and usually involve the ring and small metacarpals, fractures of the fifth metacarpal neck are far more common in people who hit solid objects such as walls. This causes impact on the dorsum of the metacarpal head and comminution of the volar metacarpal neck with dorsal apex angulation **(Fig .2)[7].**

Fig. (2): X ray AP view shows a boxer fracture of rt 5th metacarpal ***[8].***

B. Metacarpal Shaft Fractures:

There are four types of metacarpal shaft fractures: transverse, oblique, spiral, and comminuted. A direct blow usually results in a transverse, oblique, or comminuted shaft fracture. An indirect blow or rotational torque can result in a spiral fracture ***[9].***

i. Transverse Fractures:

They are usually the result of a direct blow, and they generally angulate dorsally because of the interosseous muscles exerting a volar force. The more proximal the fracture from the metacarpo- phalangeal joint, the more pronounced the dorsal angulation will be **(Fig.3)** ***[4].***

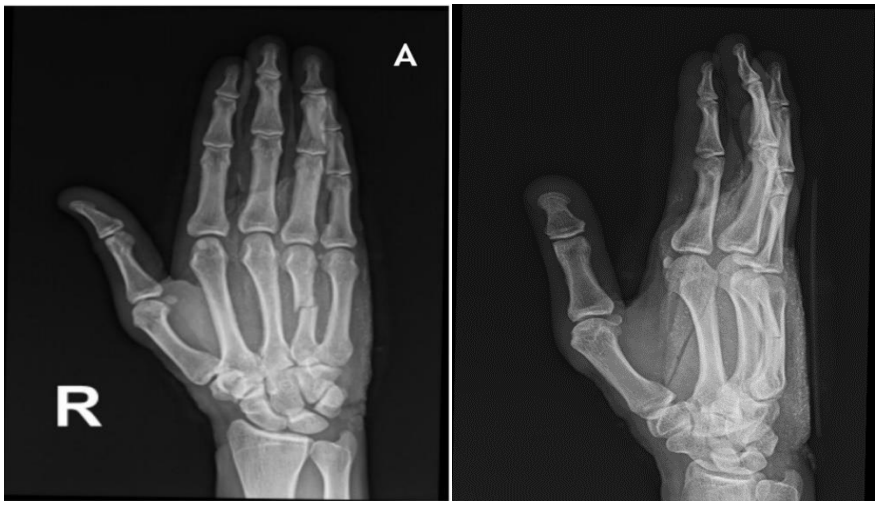

Fig. (3): Minimally displaced transverse fourth metacarpal fracture in the right hand of 35 years old male A; AP, B; lateral**.** ***[10].***

ii. Spiral / Oblique Fractures:

These fractures result from torsional force with the finger acting as long lever. They tend to shorten rather than angulate. The third and fourth metacarpals tend to shorten less because of The tethering effect of the deep transverse metacarpal ligaments while the fifth metacarpal tends to shorten more **(Fig. 4)** ***[6].***

Fig. (4): Oblique view shows spiral fracture in the right third metacarpal bone of 30 years old male ***[11].***

iii. Comminuted Fractures

These fractures are usually the result of high energy trauma and are trembly unstable. The are frequently associated with significant soft tissue injury and swelling **(Fig. 5)** ***[6].***

Fig. (5) : AP view shows comminuted fracture in the left fifth metacarpal bone**.** ***[12].***

C. Metacarpal Base Fractures And Carpometcarpal Fracture-Dislocations

Isolated intra-articular fractures of the base of the second and third metacarpal are rare because of the lack of motion on these joint, these fractures are usually the result of a fall on a flexed wrist. Isolated Ring finger Metacarpal fractures should raise the possibility of an associated CMC joint injury. Intra-articular fractures of the hamate-fifth metacarpal joint are common and are usually associated with proximal and dorsal subluxation of the metacarpal. The injury result from a longitudinal directed

force along the fifth metacarpal resulting in proximal and dorsal subluxation of metacarpal base **(Fig.6)** ***[6].***

Fig (6) ; Postero -anterior and lateral radiographs (A and B) of the left carpus demonstrating dorsal dislocations of the index, middle, ring and small carpo-metacarpal joint. The fractures of the third metacarpal and trapezium are also visible **[13]**.

Treatment of Metacarpal Fractures

The majority of hand fractures can be treated non-operatively. Acceptance of mild deformity is often preferable to surgical treatment ***[9].***

Closed reduction of shaft fractures often can be obtained by downward pressure on the dorsal apex of the fracture and upward pressure through the flexed MCP joint. Closed treatment for fractures that showed no rotational malalignment on clinical examination were treated by a short arm cast with the wrist in 30-40 degrees of extension and added a dorsal extension block to hold the MCP joints flexed 80-90 degrees and the interphalangeal (IP) joints extended and the cast was maintained for 4 weeks. This position limits joint contractures and maintains the Bones in a relaxed position **(Fig.7)**[14].

Fig . (7): short arm cast with the wrist in 30-40 degrees of extension **[15].**

Surgical management of metacarpal fractures:

Indications for surgery include:

1. Open fractures
2. Intraarticular fractures
3. Angulation of the fracture greater than 30 degrees
4. Rotational deformity greater than 10 degrees and gross (>5mm) shortening of the metacarpal.
5. Irreducible or unstable fracture.
6. Multiple digit involvement.

If the fracture is open, or a compound

fracture, this requires formal debridement and irrigation, as well as appropriate antibiotic cover, and this can be done with reduction with or without fixation. Human bites, including the fight bite scenario, require intravenous antibiotics ***[16].***

Metacarpal head fractures require operative fixation when there is a significant defect in the articular surface or instability is detected on the exam. Fractures with large articular pieces are readily fixed with small screws, while condylar plates are useful in injuries with metaphyseal extension. For those fractures that are extensively comminuted, K-wire fixation is appropriate, as small fragments do not provide adequate screw purchase. However, for both options must be immobilized fortwo weeks ***[14].***

Metacarpal neck fractures can be reduced by the **Jahss maneuver** (flex metacarpophalangeal joint, proximal interphalangeal joint, and distal interphalangeal joint, and use the curled-up finger to push themetacarpal head back into position) **(Fig. 8)** [17].

There are several surgical indications for metacarpal neck fractures. Firstly, open fractures are an absolute indication for irrigation, debridement, and fracture reduction. Secondly, if there is extension of the fracture into the metacarpal head with greater than 1 mm of displacement or any intra- articular fracture fragment blocking joint motion, surgery is recommended ***[18].***

Fig. (8); A. X ray AP view cross wires fixation of rt5 neck fractures of small metacarpals. Closed reduction using **Jahss** maneuver and percutaneous crossed wires [19].

Intra-articular fractures deserve special consideration. A step off >1mm or involvement of more than 25% of the articular surface are indication for operative fixation to align the joint and minimize the risk of subsequent arthrosis**[9].**

Finally, and most commonly, the degree of volar angulation and displacement is used to determine operative versus nonoperative

management. If volar angulation is not corrected, patients can have a prominent dorsal deformity, decreased grip strength, a prominent palmar metacarpal head and pseudo clawing.

The degrees of volar angulation for each digit that may beconsidered for surgical fixation are:

- 15º for the index finger
- 25º for the long finger
- 35º for the ring finger
- 45º for the small finger ***[18].***

Two different techniques for Closed Reduction and fixation of neckmetacarpal fractures:

A) Cross pinning

B) K. wire

Benefit of those technique are good post -operative range of motion(97, 7% compared to contralateral side) **[19].**

While the benefits of the technique of open reduction and internal fixation by (plate and screw**) (Fig. 9) are**:

A) Most biomechanically stable construct ***[20].***

B) Can used to treat multiple concurrent metacarpal neck fractures ***[18].***

C) Can be used when significant comminution precludes closed reduction and percutaneous pinning***[18].***

Fig .(9) ; A/P view x ray plate and screw fixation of the it 5th metacarpal neck fracture ***[19].***

For metacarpal shaft fractures, simple closed reduction and immobilization may be used to treat stable fractures ***[6].*** Indications for surgery of metacarpal shaft fractures include greater than 10° of angulation in the index or middle finger metacarpal, or greater than 30°–40° of angulation in the ring or small finger. In addition, open and multiple metacarpal fractures are often best treated surgically. Any rotational malalignment must be corrected. May be treated with K-wires, intra-osseous wires, lag screws, or plates, depending on the morphology of the fracture line. Lag screw can provide strong fixation and allow early reduction for long oblique fracture but should only be used if fracture is at least twice the width of the metacarpal bone (**Fig. 10)** ***[20].***

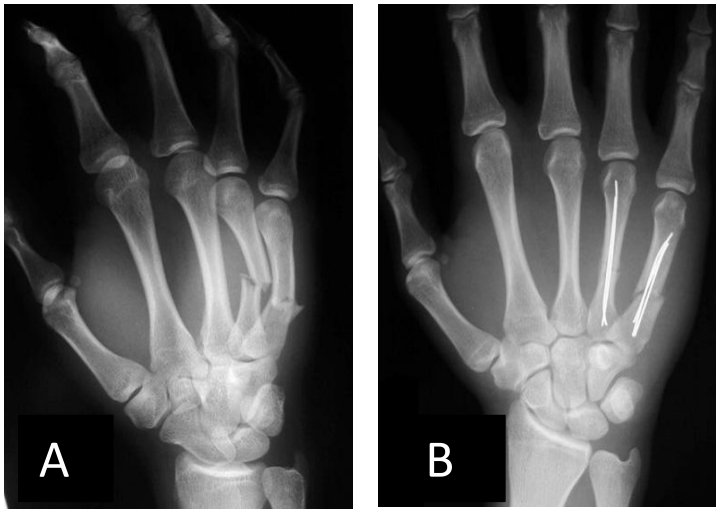

Fig. (10): A; Oblique radiograph of right 4th and 5th metacarpal fractures. B; AP radiograph of 4th and 5th metacarpal fractures following close reduction and fixation with pinning. **[21].**

Metacarpal base fractures can present as both extra and intra-articular injuries. For extra-articular base fractures, many of them occur in the meta-diaphyseal junction and can be sufficiently fixated percutaneously with K-wires to avoid devascularizing fracture fragments, but sometimes require an open approach with plate and screw fixation for direct visualization in complex fracture types. For intra-articular fractures, percutaneous pinning is again the preferred treatment method for the ring and small fingers. However, for the index and long fingers, open reduction with plate and screw **(Fig.11)** ***[14].***

Fig. (11); A; Preoperative radiographs show base fracture of 5th metacarpals, avulsion fracture of hamate and dislocation of 5th carpometacarpal joint. **B;** Reduction was achieved by closed reduction and percutaneous fixation with k-wires ***[21].***

Open fractures

Open fractures should be treated with topical wound dressing and antibiotics. Despite the controversy, health care providers should use their best judgment regarding timely debridement with dust/debris removal and primary or secondary wound closure in acute conditions. For example, treatment of bite injuries is best performed with formal surgical irrigation and debridement of the

metacarpophalangeal joint because of the high risk of infection with local debridement only in an emergency room**.** In case of doubt, the clinician should consult with the facilities on-call surgical service. Extensive open fracture patterns and soft tissue injury may require subsequent/serial irrigation and debridement procedures, depending on the extent of the injury. Occasionally, second look debridement 1 to 3 dayslater may be necessary ***[22].***

Rigid fixation of the skeleton is required to repair overlying soft- tissues injuries successfully. True rigidity is achievable with plates or an external fixator ***[17].***

Flexor tendon injury:

Flexor tendon injuries frequently complicate lacerations to the palmar surface of the digit and hand and can be subcategorized as partial lacerations, complete lacerations, and tendon avulsion injuries. Flexor tendon injuries can occur secondary to a sharp object (i.e., glass or knife), or result from blunt trauma in strength-based sports (i.e., football, basketball, wrestling), where injuries are found to occurat tendinous attachments to the bone ***[23].***

Zone I injuries:

It includes FDP tendon laceration distal to the insertion of FDS tendon or avulsion from its insertion at the base of the proximal aspect of distal phalanx. Avulsion injuries or "Rugger jersey finger" are most common in young male athletes participating in contact sports, during forced extension with maximal profundus contraction. The ring fingeris most commonly involved, as it is the longest digit when the PIP joints are fully flexed ***(Sabapathy 2016) [24].***

The following types of avulsion injuries are categorized under the Leddy classification:

Type I - FDP retracts into the palm; requires repair within 1 week, as the myotendinous unit will shorten and the tendon will weaken without nutrition. There is a concomitant rupture of the vincula, compromising blood supply.

Type II - FDP tendon avulses with a small fragment of the distal phalanx, and the tendon retracts to the level of PIP joint (A3 pulley); repair can be delayed up to 6 weeks. The long vinculum is spared, thus preserving bloody supply.

Type III - large bony fragment is avulsed with the tendon to the level of A4 pulley and is prevented from retracting beyond middle phalanx.

Type IV - combination of tendon avulsion from a fragment of tendon retraction and avulsion fracture of distal phalanx ("double avulsion") ***[25].***

Zone II injuries:

It is historically associated with poor results. Secondary to the risk of adhesion formation, the difficulties encountered during treatment, and lack of satisfactory clinical outcomes, the term no man's land was originally used by Bunnell to describe zone 2 tendinous injuries. Repair of both FDP and FDS is advocated by most, should more than 60% of cross-sectional tendon area be disrupted **[26].**

And associated with phalanges and metacarpal bone fractures, sever comminuted head fractures required external fixation or metacarpophalangeal fusion. angulated metacarpal neck reduced and fixed by K-wires or plating ***[27].***

However, in cases of massive injury (i.e. replantation), an FDP- only repair is acceptable. If emergent repair is not performed, the wound should be thoroughly irrigated and skin loosely approximated, with administration of Tetanus prophylaxis and antibiotics, following which it is advised the patient be placed in a dorsal splint. Repair can generally be completed up to 3 weeks following injury, however, delay in treatment beyond 3 weeks is associated with less satisfactory outcomes **(Fig.12)**[5].

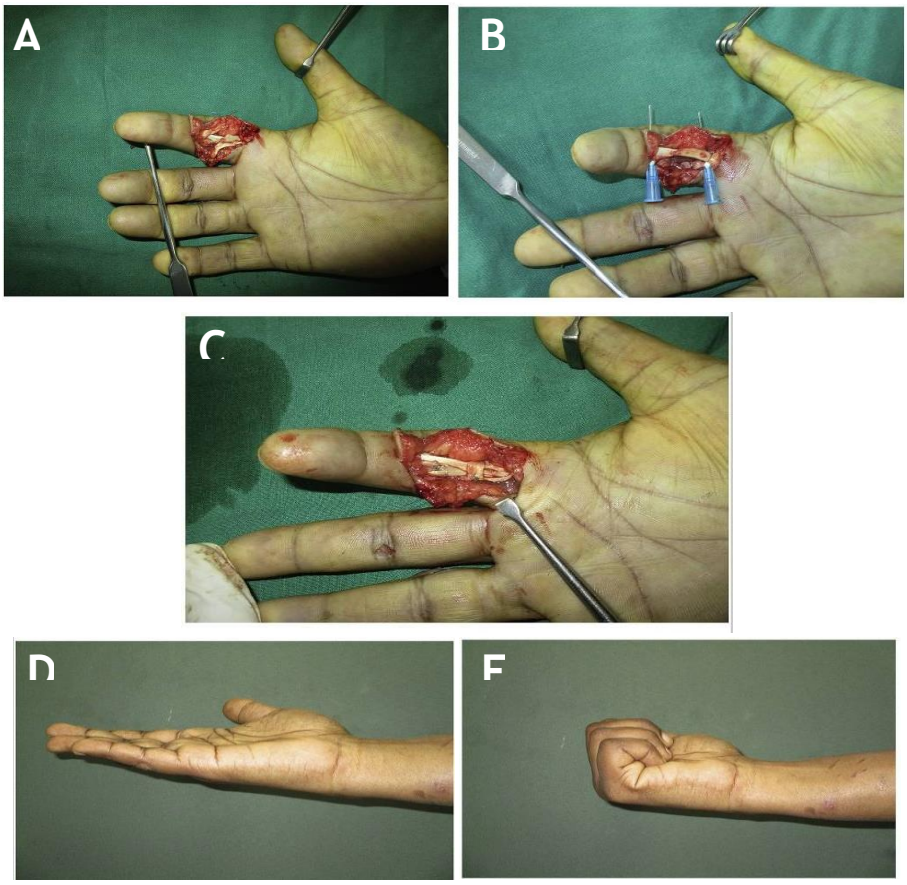

Fig. (12); Zone-II flexor tendon injury, treated with primary repair followed byearly passive mobilization protocol ***[28].***

Zone III injuries:

Although the operative repair technique remains the same as for zone II, the prognosis is better than for zone II, with functional outcomesprimarily dictated by results of associated nerve repair. Given its lack of sheath, zone III injuries generally preclude a good prognosis, when not linked with neurovascular trauma ***[28].***

Injury to the deep motor branch of ulnar nerve and/ or deep palmar arch, are to be repaired before addressing flexor

tendons. Lumbrical plus finger can result from repair in this region, secondary to excessive advancement, and results in paradoxical IP joint extension with attempted forceful flexion***[25].***

Zone IV injuries:

Operative repair is similar to zone II, with recommendations for transverse carpal ligament repair after tendon repair to prevent bowstringing. Most tendinous injuries are combined with median (asit is the most superficial structure in the carpal tunnel) or ulnar nerve injury; pure tendon injuries are rare, in part due to the protection of the flexor retinaculum***[29].***

Direct tendon repair is the gold standard in zone 4 injury management. If possible, tendons should be repaired proximal or distal to the carpal tunnel, without releasing transverse carpal ligament (TCL) ***[30].***

Zone V injuries:

Disability here is more commonly a sequela of associated median or ulnar nerve injury, and results in more disability as opposed to isolated tendon injuries. Acute injuries within zone V may be repaired within 3 weeks, after which, permanent shortening occurs, and reconstruction or

tendon transfers may be required. The most important factor in repair for zone V injuries is suture strength ***[31].***

Here, should the distal tendon ends have retracted into the carpal tunnel, the TCL should be released to permit exposure. For injuries >7 days old, the surgeon should be prepared to perform nerve grafting for median nerve injuries. Simple lacerations, lacerations with an isolated tendon injury, and lacerations with associated nerve injuries can be debrided and closed in the emergency room, in the setting of a well- vascularized digit ***[23].***

Individual tendons should be inspected on each finger. Flexor digitorum profundus (FDP) can be isolated by blocking PIP flexion and assessing active DIP flexion, as FDP is the only flexor tendon to traverse the DIP joint. Flexor digitorum superficialis (FDS) is examined by preventing flexion of other digits and evaluating isolated PIP flexion, as all FDS tendons share a common muscle belly (**Fig.13)** ***[5].***

Fig. (13): A; examination of flexor digitorum superficialis tendon, **B**; examination of flexor digitorum

profundus tendon***. [32].***

Loss of digital flexion and normal **"flexor hand cascade"** (tenodesis effect) is consistent with complete tendon transection, where there is an absence of normal flexor tone with passive wrist extension. Painful digital flexion is suggestive of a partial tendon injury. FDP avulsion injuries may present with a clinically painful nodule, indicative of a retracted tendon **(Fig. 14)** ***[23]*** **.**

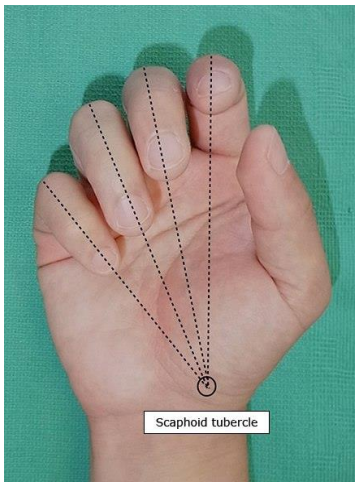

Fig. (14): The direction of the fingers when flexing to make a fist: pointing towards the area of the scaphoid tubercle (normal cascade sign) [33].

Treatment

Before discussing surgical options and timing, it is important to note that not every flexor tendon injury is expedited to the operating room on initial presentation. As patients present to clinic, the emergency department, urgent care, or other primary setting, initial treatment usually consists of IV antibiotic administration, thorough debridement of the wound basin with removal of foreign debris and inspection of tissue viability, followed by loose skin closure, appropriate splint application to limit proximal tendon retraction, and education on the importance of compliance with early follow-up ***[29].***

If the tendon is lacerated and the distal tendon stump is <1 cm, FDP tendon advancement and primary tendon-to-bone repair is usually indicated; if >1 cm remains, primary tendon repair can be performed to avoid unnecessary shortening of the flexor tendon ***[31].***

Either suture anchors or pull-out button technique can be orchestrated, with several studies demonstrating superior arc of motion, patient-rated outcomes, lower complications, and shorter return to work following anchor repair versus buttons. Furthermore, data has shown that anchors represent a biomechanically superior construct that can withstand the stresses of early active motion protocols **[29].**

Tendon Repair with Referral to timing: -

1) Primary tendon repair is end to- end repair performed immediately usually within several to 24 hours after trauma ***[34].***

2) Delayed primary repair is defined as end-to-end repair performed days to weeks after tendon injuries (usually within 3, or even 4, weeks after tendon lacerations), after immediate closure of the wounds without tendon repairs ***[34].***

3) Early secondary repairs are performed between 3 and 5 weeks ***[35].***

4) Late secondary repairs are performed 5 weeks or more and require tendon substitution procedures rather than

direct tendon repair ***[36].***

Tendon Repair Techniques (Fig. 15, 16):

A) Tsuge

B) Modified graping kessler

C) Modified Locking

D) Modified Pennington

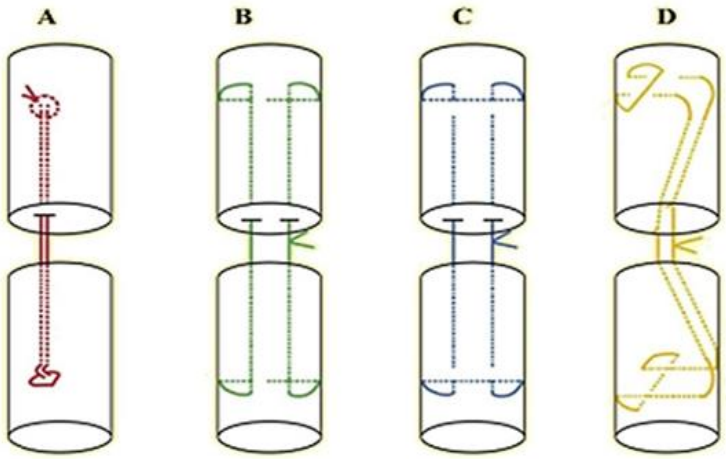

Fig.(15): Examples of two strand repair techniques: A-Tsuge, B-Modified grasping Kessler, C-Modified locking Kessler, D-Modified Pennington **[37].**

A) Double Modified Kessler
B) Cruciate Non Locked
C) Cruciate Cross Stitched Locked
D) Four Strand Savage
E) Augmented Becker
F) Six strand Savage
G) Modified Savage
H) Triple Modified Kessler

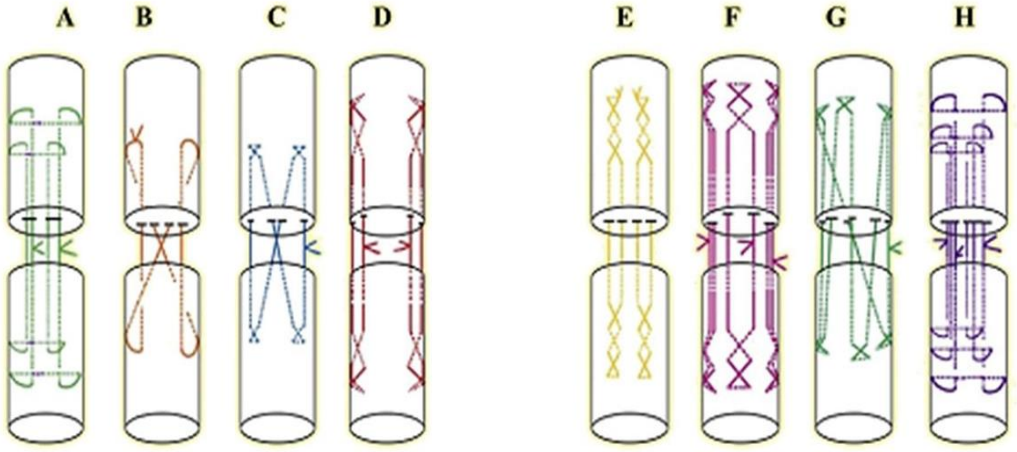

Fig. (16): Examples of four and six strand repair techniques: A-Double modified locking Kessler, B-Cruciate non locked, C-Cruciate cross stitched locked, D-Four strand Savage, E- Augmented Becker, F- Six strand Savage, G- Modified Savage, H-Triple modified Kessler ***[38].***

Tendon Grafting:

It is utilized for repair in the setting of segmental tendon loss or muscular contracture. Indications for tendon grafting include failure of flexor tendon repair, injuries resulting in segmental tendon loss, delay in repair that obviates primary repair, severe crush injuries with segmental tendon loss, lacerations that have been neglected for more than 3-6 weeks, patients in whom the surgeon believes delayed grafting is the better treatment alternative, suspicion of wound infection, closed rupture in zone I to zone III, or for delayed presentation of FDP avulsion injuries associated with significant tendon retraction***[29].***

Single-stage repairs require adequate tendon sheath and pulleys,soft tissue coverage, and supple joints. The injured tendons are excised and replaced with a suitable tendon graft that is secured to the base of distal phalanx at FDP insertion and joined to a proximal motor in the palm or distal forearm ***[24].***

Two-stage repair is used when tendon sheath is scarred or unusable,in cases of pulley incompetence, joint contracture, inadequate passive range of digital motion, or following crush injuries with extensive soft tissue damage and underlying fractures. ***[23].***

The first procedure consists of thorough digital exploration, reconstruction of associated injuries, and placement of a passive silicone tendon implant that allows for correction of joint contracture, reconstruction of pulleys, and formation of a pseudo sheath. This is subsequently followed by therapy to regain and maintain PROM for 6-12 weeks ***[28].***

The second stage proceeds thereafter, with placement of an extrinsic-free donor tendon graft that is fixed to the distal end of previously implanted rod and pulled proximally through pseudo sheath; the implant is then removed and the tendon graft is suturedto proximal flexor stump with corrective tensioning. This salvage/ reference option is termed the Hunter technique **[31].**

Potential sources for donor graft include palmaris longus, plantaris, extensor digiti minimi, extensor indicis proprius, or toe tendons. Intra- synovial tendon grafts may afford distinct advantages over extra-synovialtendons. Their association with less tenocyte death and fewer peri-tendinous adhesions has been well documented ***[30].***

Tendon Transfer:

It has limited indications for flexor tendon repair, however, can be considered when proximal musculature is deemed unusable because of denervation, direct injury, or contraction ***[28].***

General Principles in Tendon Surgery:

Flexor tendon repairs should be performed under loupe magnification in the operating room, while maintaining viability of skin flaps, permitting wide exposure, and prohibiting formation of scar contractures, with minimal traumatic handling of the tendon surfaces to limit subsequent adhesion formation ***[39].***

It is important to recognize the location of skin laceration may be different than the site of the tendon injury, based on

extension/flexion position of the digit at time of insult. Initial strength of repair is proportional to the size and number of suture strands crossing the repair site***[5].***

The **Pulvertaft** weave technique interloops the proximal and distal tendon ends and is suitable for tendon grafts or transfers. The addedbulk provided by weaving prohibits the use of this technique outsideof zone III / IV. As the strongest method, it is capable of withstanding immediate active motion**(Fig.17)** ***[28].***

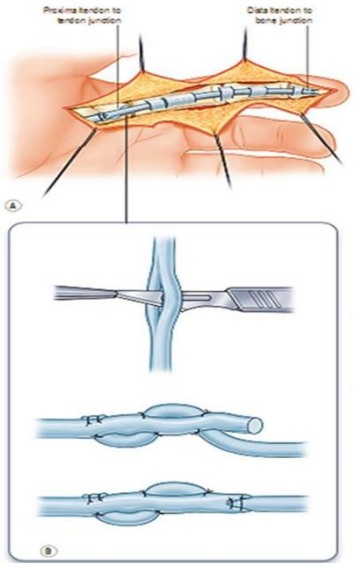

Fig. (17): **(A)** the tendon junctions are placed outside the flexor sheath region. the Pulvertaft weave technique is commonly used (shown in detail in **B).** The junction is placed at either palm or distal forearmted by a knife **[40].**

Every effort should be employed to preserve or reconstruct at leastA2 and A4 pulleys. An incompetent pulley system leads to volar translation or "bowstringing." Pulley reconstruction should ensuresufficient length and tension to hold tendons near the bone but not restrict tendon excursion, while restoring the position of flexor tendons in the tendon sheath ***[30].***

Wide Awake Local Anesthesia Technique, (WALAN) surgical technique for flexor tendon repair is also recommended to permit necessary adjustments of tendon repairs. There are numerous advantages to employing WALANT technique: reduced costs, no tourniquet**,** no sedation nor need for an anesthesiologist, intraoperative patient education, and a direct view of repair ***[28].***

Post Optative Care

Degrees of flexion, maintaining interphalangeal joints in near full-extension or slight flexion (15 degrees). Sutures are removed after 2weeks & cast left for 6 weeks ***[23].***

Extension block-splints should position the wrist in 30 degrees of flexion to take tension off flexor tendon repairs and minimize the risk of postoperative tendon rupture, with metacarpophalangeal joints in 45-70 Between the 2nd and the 5th days of the post-operative period, dorsal splint and Kleinert protocol began to be implemented. Kleinert splint is used in a modified form ***(Fig.18) [24].***

Fig .(18): Photograph of thermoplastic splint typically used in early active mobilization protocols **[41]**.

Modifications are as follows:

- Decrease in wrist flexion 0-30.

- Increase in metacarpophalangeal joint (MP) flexion 60-80.
- Palmar pulley usage. Combined nylon thread and elastic band usage.
- Loosening the nylon threads and elastic bands from pulleys at night.
- Including all of the fingers in elastic band traction.
- Including passive range of motion in the program ***[5].***

Through advancements in biomechanical and clinical research, there isa general understanding that early therapy guided tendon excursion is more beneficial than strict immobilization, in efforts to achieve maximal functional recovery. Mobilization promotes intrinsic tendon healing, increases tensile strength, and decreases adhesion formation, while improving tendon gliding - all benefits which translate into optimized joint motion, fewer flexion contractures, and overall, enhanced functional enhanced functional outcomes ***[42].***

Various recommendations include early, controlled passive range of motion with a goal of at least 2-4 mm of differential gliding between FDSand FDP, and/or elastic band traction for active extension and passive flexion, with multiple variations and modifications of these protocols in place ***[39].***

Postoperative rehabilitation is largely influenced by patient compliance.Although general guidelines are implemented for various therapeutic interventions, regimens are accelerated and decelerated based on individualized adherence and subsequent response to therapy. Return to work can take several months. Approximately 10% of patients may require secondary surgeries for complications, thus, the importance of adherence to postoperative therapy must be stressed, to optimize functional outcomes[24].

Complication:

Tendinous extrinsic healing component acts as the culprit of adhesion formation between the tendon and its surrounding fibro-osseous sheath. Adhesions with resultant digital stiffness remain one of the most common complications after flexor tendon repair. Adhesion formation with subsequent restriction of tendon excursion prompts the need for tenolysis ***[24].***

Infection, skin flap necrosis, mechanical failure of implant (if used), pulley disruption, swan neck deformity, infection and synovitis are also possible complications followingoperative therapy for flexor tendon injuries ***[29].***

Reference:

1. **Schöffl V, Heid A and Küpper T (2012).** Tendon injuries of the hand. World J Orthop. 2012 Jun 18;3(6):62-9.
2. **Bagul R , Salgia A and Agarwal T (2013).** Compound fracture of the first metacarpal with volar dislocation of second, third and fourth carpometacarpal joints. Medical Journal of Dr. D Y Patil University, 6(4), 472. doi:10.4103/0975-2870.118297
3. **Rashed R, Hegazy G and Abusamada HSAA (2019).** Results of Treatment of Oblique and Spiral Phalangeal Fractures of the Hand by

Mini Lag Screws. Egypt J Hosp Med. 2019; 76(4):3882-3890

4. **Josh bloom (2022).** metacarpal head fractures, editor: Jonathan grayzed, Up To Date, https://medilib.ir/uptodate/show/187
5. **Wolfe S , Pederson W and Kozin S (2021**). Green's operative hand surgery, Flexor Tendon Injury; Elsevier Health Sciences, edtion8. chapter 6, pages (193-198). ISBN: 9780323697941
6. **Scott W, William C and Scott H et al., (2021).** Green book of hand surgery,8th Edition, pages (239_290) Hardback ISBN: 9780323697934
7. **Leung Y , Beredjiklian P and Monaghan B (2002).** Radiographic assessment of small finger metacarpal neck fractures. J Hand Surg Am. 2002;27(3):443–8.
8. **Hussain M , Ghaffar A and Choudry Q, et al. (2020).** Management of Fifth Metacarpal Neck Fracture (Boxer's Fracture): A Literature Review. Cureus 12(7): e9442. doi:10.7759/cureus.9442**.**
9. **Kollitz K , Hammert W and Vedder N et al., (2014**). Metacarpal fractures: treatment and complications. Hand (New York, N.Y.), 9(1), 16–23.
10. **Martinez-Martinez F, Moreno-Fernandez J and Rotella P (2015)**. Spontaneous rupture of extensor tendons of the index finger. A report of two cases. Hand (New York, N.Y.), 10(3), 570–573. doi:10.1007/s11552-014-9709-8.
11. **Yonso M (2023).** 3rd metacarpal fracture. Case study, Radiopaedia.org (Accessed on 23 Dec 2023).
12. **Mohsen El Alfy, M (2017).** Metacarpal fractures: Current concepts of management. Orthopedics and Rheumatology Open Access Journal, 8(5).
13. **Rubin G, Orbach H and Rinott M (2016).** Complex Dorsal Metacarpophalangeal Dislocation-Long-Term Follow-Up. J KHand Surg.Am. (6-14-2016).
14. **Werntz R and Varacallo M (2023).** Metacarpal Fracture. [Updated 2023 Aug 4]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2023 Jan-.
15. **Fernández-Bran B, Sanmartín-Fernández M and Couceiro-Otero J (2017).** Rehabilitación domiciliaria en el tratamiento postoperatorio de la reparación de los tendones flexores. Rev Esp Cir Ortop Traumatol. 2017;61:224---232.
16. **Meinberg E , Agel J and Roberts C et al., (2018).** Fracture and dislocation classification compendium—2018. J Orthop Trauma. 2018;32:S1-S10.
17. **Meals C and Meals R (2013).** Hand fractures: a review of current treatment strategies. J Hand Surg Am. 2013;38(5):1021–31.
18. **Leinberry C , Ukomadu U and Ilyas A (2013).** Metacarpal Fractures and Carpometacarpal Fracture-Dislocations. 1st ed. New Delhi, India: Jaypee Brothers Medical Publishers Ltd; 2013.
19. **Padegimas E , Warrender W and Jones C et al., (2016).** Metacarpal Neck Fractures: A Review of Surgical Indications and Techniques. Arch Trauma Res. 2016 May

23;5(3):e32933.

20. **Jones N , Jupiter J and Lalonde D (2012).** Common fractures and dislocations of the hand. Plast Reconstr Surg. 2012;130:722e–36. doi: 10.1097/PRS.0b013e318267d67a.
21. **Yi W , Chung and Y Heo (2008).** Journal of the Korean Fracture Society.
22. **Balaram A and Bednar M (2010).** Complications after the fractures of metacarpal and phalanges. Hand Clin. 2010 May;26(2):169-77.
23. **Ramponi D, Ramirez E and Hoyt K (2016).** Management of hand injuries: Part II. Advanced emergency nursing journal, 38(4), 266-278.
24. **Sabapaty, S. R. (2016).** Treatment of mutilating hand injuries: An international perspective. Hand Clinics, 32(4), 435-602.
25. **Tang, J. B. (2022).** Flexor Tendon Injuries. In Plastic Surgery - Principles and Practice (pp. 730–749), ISBN 9780323653817.
26. **Klifto C , Capo J and Sapienza A et al., (2018).** Flexor tendon injuries. JAAOS-Journal of the American Academy of Orthopaedic Surgeons, 26(2), e26-e35.
27. **Fufa D and Goldfarb C (2012).** Fractures of the thumb and finger metacarpals in athletes. Hand Clin.28(3):379-88.
28. **Venkatramani H , Varadharajan V and Bhardwaj Pet al., (2019).** Flexor tendon injuries. Journal of clinical orthopaedics and trauma, 10(5), 853-861.
29. **Stevens K, Caruso J and Fallahi AKM et al., (2022).** Flexor Tendon Lacerations. In StatPearls [Internet]. StatPearls Publishing.Vikant, 2023J Hand Microsurg. ; 8(1): 2–12.
30. **Lahiri A (2019).** Managing mutilating hand injuries. Clinics in plastic surgery, 46(3), 351-357.
31. **Goldfarb C , Puri S and Carlson M (2016).** Diagnosis, treatment, and return to play for four common sports injuries of the hand and wrist. Journal of the American Academy of Orthopaedic Surgeons, 24(12), 853-862.
32. examination of flexor digitorum superficialis tendon, B; examination of flexor digitorum profundus tendon. (www.orthobullets.com 2021).23/ 1/ 2023
33. **https://foreonline.org/wp-content/uploads/ 2017/05/34_Hand-fractures-that-can-be-treated-closed-with-success-4-by-3-NXPowerLite-Compatibility-Mode.pdf. 4/ 2/ 1023.**
34. **Tang JB (2013).** Outcomes and evaluation of flexor tendon repair. Hand a.clin. 29(2):251-9.
35. **Frueh F, Kunz V and Gravestock I et al., (2014**). Primary flexor tendon repair in zones 1 and 2: early passive mobilization versus controlled active motion. J Hand Surg Am. Jul; 39(7): 1344-50.
36. **Elliot D, Barbieri C and Evans R et al., (2007**). IFSSH Flexor Tendon Committee Report . J Hand Surg Eur Vol. Jun; 32(3):346-56.
37. **Mehling I , Arsalan Werner and Sauerbier M (2014**). Evidence-based flexor tendon repair. Clin Plast Surg. Jul;41(3):513-23.
38. **Goggins T, Syme D and Murali S (2014).** (iv) Acute flexor tendon injury

and rehabilitation of hand injuries. Orthopaedics and Trauma, 28(4), 219–224.

39. **Barthel P and Mansat P (2012).** 24 Single-stage Grafting For Free Flexor Tendon Injury In Fingers. Tendon Surg of the Hand E-Book. 23:266.
40. **Torrie P, Atwal N and Sheriff D et al., (2010**). (vi) Flexor tendon injuries. Orthopaedics and Trauma, 24(3), 217–222.
41. **Benameur H, Bensaleh S and Chagou A et al., (2022).** Comparison of Modified Kessler and McLarney Techniques in Zone II Flexor Tendon Repair. Cureus, 14(9).