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Duran And Kleinert Techniques In Flexor Tendon Rehab: A Comparative Analysis

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ABSTRACT

Background/Objective- Flexor tendons injuries are one of the most common serious injuries to flexor tendon (flexor digitorum profundus and flexor digitorum superficialis) which are result of lacerations or trauma. The only option of treatment is end to end surgical repair, after which rehabilitation plays a very important role to prevent its recurrence. The aim of this study is to review the rehabilitation techniques i.e. modified Kleinert and modified Duran protocol for flexor tendon injuries.

Material and method- A systematic review is done to summarize the benefit of the combined techniques i.e. modified Kleinert and modified Duran protocol.

Out of the 28 articles, 10 articles fulfilled our requirement and were put in the inclusion criteria. 18 articles were put in the exclusion criteria as they did not meet our requirement. All the 10 included articles said that modified Kleinert and modified Duran protocol when used in a combination is more successful than when used individually.

Result- The result of the review states that the benefit of using the combined protocol is significantly greater than the benefit of using the individual techniques.

Discussion- This review incorporates studies that recommend both protocols and propose a change in the technique to allow for movement while avoiding complications of extension. Functional outcomes tend to be better when a balanced rehabilitation protocol is followed as suggested by the review findings.

Conclusion- This review found out that modified kleinert and modified duran protocol when used in a combination is more successful and productive.

Keywords: *flexor tendon injury, modified kleinert technique and modified duran technique*

1. INTRODUCTION

Injuries to flexor tendons of the hand, which include the flexor digitorum superficialis and the flexor digitorum profundus, are almost always the result of lacerations from knives or glass, crush injuries, and the rare avulsion of the insertion site at bone during contact sports like football, rugby, and wrestling [5]. These injuries can be classified as either acute or chronic and as direct or indirect flexor tendon injuries [7]. The incidence of such flexor tendon injuries and tendinopathy is in the range of 7-14 per 100,000 populations and is reported to be most common in the Indian population. Approximately 5% of these injuries require surgical repair of the flexor tendons. A study done by Venkatramani et al in a Finnish population estimates the affected number to be approximately 7:100,000 people per year. Among children below 16 years of age, 31 out of 391 flexor tendon injuries were recorded [6]. There is a high incidence among males, particularly those aged 20 to 29 years, with work-related injuries constituting 25% of acute cases. Tendons problems tend to show a critical level underuse, while the signs and symptoms demonstrated include inability to bend/move affected multiple joints of arm or hand, numbness, and tingling. Resting posture of the hand proves some value in the diagnosis, in combination with absence of the tenodesis sign.

Treatment often involves an end-to-end surgical repair of the flexor tendons and its rehabilitation [1]. Rehabilitation is focused on the restoration of lost normal functioning of the tendon post-surgery and preventing re-injury. The primary dual protocols for rehabilitation of the flexion tendon injuries are termed as modified Duran technique and modified Kleinert. In modified Kleinert technique, there exist active extensions within the rubber band flexion or the active extension- passive flexion method [5]. True Duran technique encompasses full PIP extension to the PIP joint; while during exercise has rubber band traction which is removed in the modified Duran technique [22].

2. ANATOMY

The flexor tendons are the muscles in the forearm which ‘cross’ the wrist, palm and terminates into the fingers, enabling flexion of fingers and thumb for grasping and fist making [3]. Each digit has two flexor tendons, the flexor digitorum superficialis (FDS) and flexor digitorum profundus (FDP). The palm houses the FDS which is more superficially located to FDP, but at the level of the MCP joint, the FDS splits into two slips, permitting the FDP to pass between the two tendons becoming superficial to FDS [6]. These components of the system include the flexor tender of the hand, the forearm flexor’s muscles, specialized digital flexor sheath and sculpted tendon sheath. All parts of the system work together to allow efficient and smooth flapping motion of the four fingers including thumb at the wrist [2].

Tendons serve as the strong cords that anchor muscles to bones. They are responsible for the movement of the joints as they pull through their attachments to bones during muscle contraction and movement. The long tendons of the muscles that pass through the tunnels (tendon sheath) in the wrists and hands attach to the small bones in the fingers and thumb [3]. The tendons that are involved include the flexor pollicis longus (FPL), flexor digitorum profundus (FDP), flexor digitorum superficialis (FDS), flexor carpi ulnaris (FCU), and flexor carpi radialis (FCR) [3]. At some locations, the thickening of the fibrous sheath is referred to as pulleys.

On the basis of their resembling structures, these pulleys are annular and cruciate. For the annular pulleys, A1 to A5 are reserved and for the cruciate ones C1 to C3. In the thumb, three pulleys have been described as A1 pulley over the MCP joint, A2 pulley over the IP joint and oblique pulley which is an extension of the abductor pollicis aponeurosis running along the phalanx proximal to the first is considered the most important for FPL function. These tendons are covered with a synovial sheath filled with synovial fluid, which nourishes the tendons. Each tendon, both deep and superficial, is equipped with two vinculae, one longus (long) and one brevis (short), that supply the vascular network [6].

3. TENDON HEALING PROCESS

The healing processes of tendon consist of two main processes, extrinsic which includes the healing of the surrounding tissue, and intrinsic which involves the tendon and its synovial sheath. The extrinsic healing processes is aided by vascular and cellular ingrowth from the surrounding tissues. The forming callus permits the cicatrisation of tendon but inhibits its movement, usually in zone 2. To inhibit adhesion formation, some steroids, anti- inflammatory medicines, hyaluronic acid and antihistaminics are employed. Inhibiting adhesion formation has been made possible throuz gh the use of microsurgical techniques, new suture materials, and a non-traumatic approach. A multitude of factors such as associated lesions tend to skin, vascular and nerve injury, or fracture, and the nature of trauma which include avulsion, crush, blunt injury, and crush injury play critical roles in defining the risk of adhesions formation. Research indicates that the tendon cells, or tenocytes, contain inherent healing capabilities [20].

4. CLASSIFICATION ZONE FOR FLEXOR TENDON INJURY

The zone Classificiation of flexor tendon divides into five zones based on anatomical location. In 1983, Kleinert and Verden divided the flexor tendon injury into 5 zones as depicted in figure 2.1. Zone 2 has been recognized as “no man’s land” because of historical high rates of complications [4].

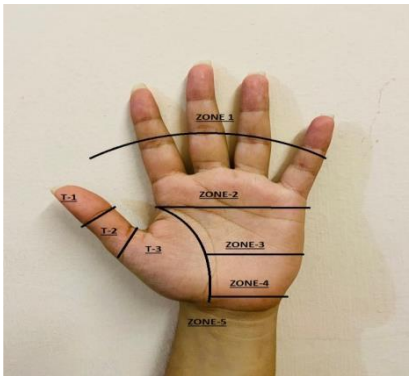


Fig.1.2 zone of classification of flexor tendon injury

REGION OF CATEGORIZATION OF FTI IN FINGERS
Zone 1: From the beginning of insertion of flexor FDS into the phalanx and the base of FDP around distal phalanx. Fist of FDP height jersey finger etc
Zone 2: From the even pulley proximal edge to the distal insertion of FDS used till the distal edge rotates round towards both transverse and sagittal planes.
Zone 3: From distal edge of the carpal tunnel to the proximal rim of the A1 pulley. Contains the origin of the lumbrical muscle which comes from distal tendon of FDP.
Zone 4: Inside the carpal tunnel.
Zone 5: From musculotendinous junction of forearm to proximal opening of carpal tunnel.

REGION OF CATEGORIZATION OF FTI IN THUMB
zone T1: From FPL insertion to A2 pulley.
zone T2: From A2 pulley to distal A1 pulley.
zone T3: From distal A1 pulley to wrist or carpal tunnel

Table 1.1 Zone of classification of FTI

Flexor Tendon Repair [29]

The purpose of FTR attempts to strike a perfect compromise between the strength of the repair and the glide of the tendon. The ideal traits of a primary FTR have been noted as follows:

- Tendon securing sutures can be placed with ease and securely.
- Join the tendon ends without a step.
- Little or no gap at the repair site, not exceeding 3 mm.
- Little (if any) disruption to the supply of blood to the tendon
- Somewhat strong enough to allow EAM

ZONE 1 REPAIR - the "button-over-nail" repair is the most utilized repair technique, which has the least range of motion at the lower DIP joint. "Shepherd's Crook" repairs I as light variation using a k-wire as an external strut instead of a button has the advantages of preventing skin pressure necrosis and structural destruction of the nail, but great risk of infection due to k-wires and poor patient compliance are drawbacks. Mouldy bone suture anchors are used instead to circumvent the morbidity from a pull-out suture repair. The main disadvantage of bone anchor is its high cost. In patients over 75 years, suture anchors may be contraindicated.

ZONE 2 REPAIR- "No man's land, repair. Two strand repairs have very high rupture rates and is not favored by surgeon. It is a suture repair with at least four strands. Four strand repair- most commonly used repair for zone 2. It is a suture repair with at least four strands."

ZONE 3 REPAIR- Utilizing a two and three "figure of eight core suture" in combination with a continuous epitendinous suture to close FDS and FDP lacerations. A favorable outcome with non-injurious external active mvmt can be achieved if there is no neurovascular compromise.

ZONE 4 REPAIR- Tendon lesions are uncommon in zone 4 because of the protection given by the flexor retinaculum. Its management include direct tendon repair and releases the transverse carpal ligament.

ZONE 5 REPAIR- Zone 5 injuries where there is a possibility of serious damage the neurovascular bundle is greatly jeopardized, as well as needing surgical repair and subsequent rehabilitation. Kessler repair have good functional and technical results on injuries to zone 5.

THUMB INJURIES REPAIR - If there is an adequate range of IP joint extension, excellent outcomes can be achieved using a six strand M Tang repair. Also, End to End repair has an excellent good outcome. Repair techniques such as motion stable Mantero technique, and Kessler 4 strand percutaneous tendon repair tend to yield insufficient mobility at the IP joints, resulting in unfavorable overall functional outcomes, hence not routinely employed in practice.

Post-Operative Management

Most of them involve active motion exercises, following which suture strength needs to be fortified.

- Active removal of extension: Kleinert Protocol – rubber band flexion with relaxation method.
- Immobilization
- Controlled passive motion methods (Duran protocol)
- Early Active ROM

Flexor Rehabilitation

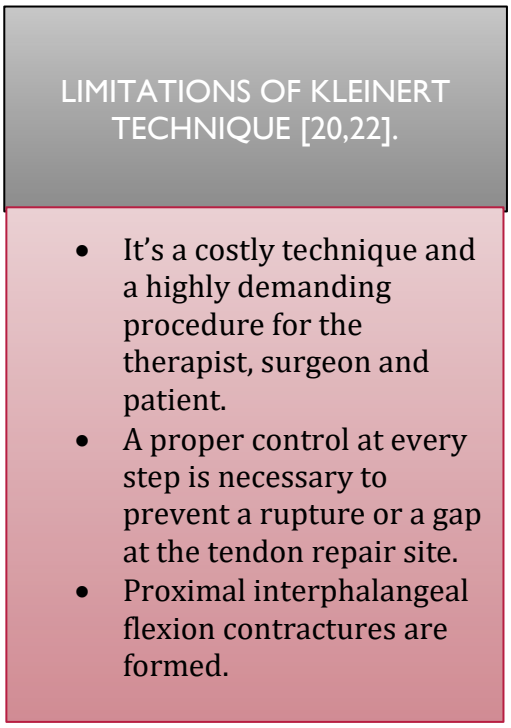
An effective rehabilitation procedure increases the mechanical properties of the tendon matrix, acts selectively on fibroblasts and capsular tissue, so that tendon healing is facilitated, reduces the formation of adhesions, tendon glide, create a range of motion restore while maintaining the structural integrity of the repair. [7]

Table no.1.3 flexor tendon repair protocol according to week [19].

Timeline	Types Of Splint	Therapeutic exercises (Tx) Achieved by Home Exercise Programs (HEP)	Precautions	Others
Week 0-3	Splinting (neutral wrist, 50 flexion of MCP) & Full Extension of IP(If repaired FDP of MF, RF or SF, include all 3 digits in splint)			
Week 3	At night, if required, begin serial static PIP extension splinting	If not attained through EAM, add: 1. placed\hold for hook, full and straight fist with wrist extended. 2. place hold for isolated FDS glide of involved digits.	Same as week 1 and 3 Gentle tension exercises should be performed. Muscle contraction should be avoided.	

Week 4	Progress splint to hand based dorsal splint	In all three fist position with wrist extended, you may begin active, non-resistive flexion and extension of the fingers		Light prehensile activities in clinic.
Week 5	Discharge splint	In PIP and DIP flexion, you may add gentle blocking exercises if needed.		Light prehensile activities at home
Week 6	If needed, start with the PIP and DIP extension splint.			If needed, start NMES and therapeutic ultrasound heating.
Week 8		To the home programs add gradually resisted exercises.		Functional use of hands.

5. KLEINERT AND DURAN TECHNIQUES



Both Kleinert and Duran Techniques are protocols of the two fundamental types of early active mobilization therapy for rehabilitating flexor tendon injuries: Kleinert (active extension, rubber band passive flexion) and Duran (passive extension, passive flexion) [23].

Kleinert Technique

In 1950, Harold Kleinert suggested the use of an adjustable wrist dorsal block plaster splint with the wrist in 20 deg. flexion, MP joint in flexion of 70 deg. and complete finger extension. After the dorsal block, fingers are maintained in flexion using a loop which is fixed to the nail and allows for active extension within the range of motion imposed by the dorsal block band splint [20, 21].

The expectation is that patients will be encouraged to extend fingers actively multiple times throughout the day, for many half-hour intervals, during the first 4 weeks. The remainder of the day and overnight, rubber band traction needs to be removed to avoid interphalangeal joint flexion contracture. At the initial exercise level, the patient's elbow is flexed and

pronated which helps relax the flexor muscles, this should be performed under guidance of the therapist hand. Dorsal Blocking Splint can be utilized for active flexion between the 5th and 6th postoperative weeks. Sprint [20].

The flexed posture and decreased controlled motion protocol set by Kleinert has also been modified by increasing flexion at the Wrist and Decreasing Flexion at the MP joints. Also all modification of the active verbalisms on the digital extension and rubber band flexion method of Kleinert consists a distal palmer bar that allows the rubber to portray a more proximal approach to the terminal digit from the distal palm which leads to almost full interdigital flexion during contraction of the rubber band. [21] Active extension in the limits of Brace 50 repetitions at the hour guarded Terms of dorsal blocking splint. In addition, passive flexion to the PIP and DIP Joints, followed each composite passive flexion to passive flexion of the finger (5 times per hour). Complication from Kleinert's protocol majorly PIP flexion contraction that accompanies the passive motion rests wherever the injured finger is extended, held in flexion position the entire time leading to creation of another passive motion protocol, that I termed the **Modified Duran protocol**. [22]

Modified Kleinert techniques, controlled passive mobilization splint are set by Kleinert, modification increasing passive ROM for PIP and DIP joints within and around the normal range is set to be used [28]. Modified Kleinert by adding Palmar Pulley to the regimen template of Kleinert improves DIP flexion. This therapy can be defined as an active extension/assisted flexion regimen as opposed to an active extension/passive flexion regimen. [27]

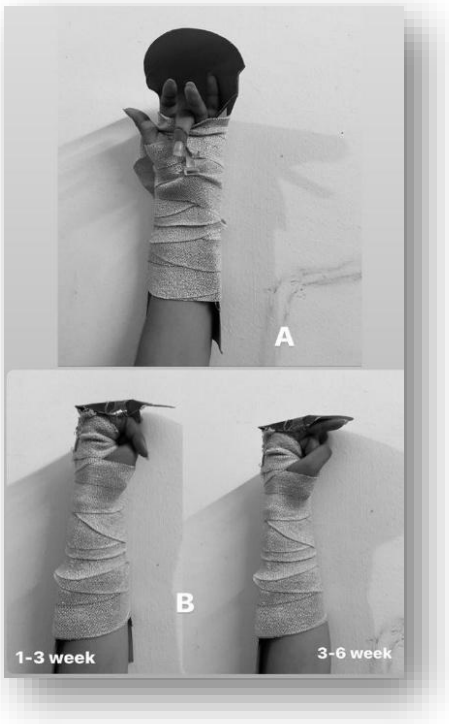


Figure 1.5 Modified Kleinert technique

Table 1.4 Kleinert Technique

Protocol	**Complete immobilization**	**Passive motion**
Dorsal blocking orthosis Wrist Metacarpal joint Proximal interphalangeal joint and distal interphalangeal joint	30˚ flexion of wrist 40-60˚ flexion of MCP joints PIP and DIP in extension	**Kleinert**: Wrist 30˚ flexion MCP in 40-60˚ flexion PIP and DIP joint in extension Involved finger immobilized with rubber band or elastic thread in full flexion. **Duran**: 20˚ flexion of wrist MCP joints in flexion PIP and DIP joint in extension Fingers positioned in extension at night

DURAN TECHNIQUES- Controlled passive motion was put forward by Duran and Hauser for the postoperative management of the flexor tendon repair in zone 2. The wrist is positioned between 20-30° of flexion, MP joint is at 60° flexion, PIP is set to flexed position but DIP is extended. For the initial 4 weeks, controlled passive motion is employed. The hand therapist performs two sessions a day, each comprising 6-8 motions per tendon. This stance is described in 4-5 minute motions at the site of repair to stave off strong adhesion build up. For a week, rubber band traction is applied to the wrist, followed by active tendon gliding and exercising over the splint for 2 weeks [20].

6. MODIFIED DURAN PROTOCOL:

Duran method was updated by Strickland. He increased the duration and frequency of daily passive exercises. Active Extension of fingers is performed along with flexion for the PIP and DIP joints during repeated movement cycles with a full range of passive extension and flexion. An occupational therapist employed by the hospital chain collaborates with the operating hand surgeon to assist with controlled passive motion protocol for the first five weeks. For starting the active flexion exercises after the fifth week, the block technique suggested by Bunnel is PIP joint with active flexion and MP joint is held in extension. After week six, dynamic splitting may be indicated if there is limited extension of the finger. The minimum period before considering any tenolysis is 6 months. Complete motion can be obtained within 20. [20]. During the period, the modified version incorporates the full length of the fingers in the orthosis, added strapping of full extension, and the rest of the orthosis is adding straps which reduce problems with PIP joint contracture [22]. Each patient is instructed to hourly perform passive flexion and active extension of individual finger joints and the whole finger [22]. The original protocol's passive exercises for the early stage permitted active tenodesis are appropriate for therapy [23].

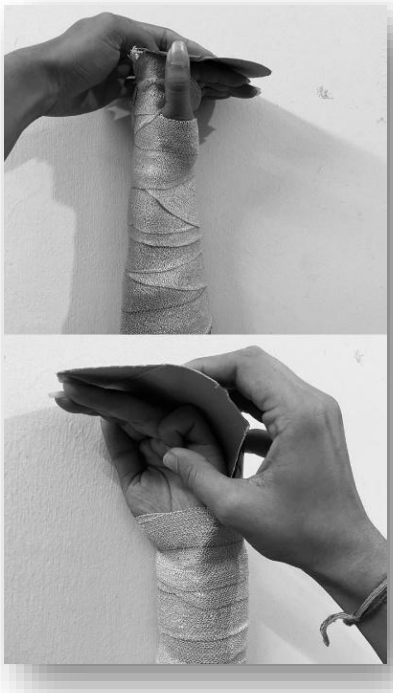


Figure 1.6 Duran Technique

Limitations

• Little finger should not participate in blocking programs. [24]

DURANS VS. KLEINERT TECHNIQUE [19,23]

	DURANS VS. KLEINERT TECHNIQUE [19,23]	
s.no.	**Duran protocol**	**Kleinert Protocol**
1.	Rubber band traction for one week	Dorsal blocking splint is used

2.	Passive extension of fingers.	Passive extension of fingers
3.	Uses dorsal blocking splint for passive flexion of fingers	Fixes the finger in passive flexion by the use of rubber band
4.	Wrist 20◦ flexed; MCP in loose flexion.	Wrist 30◦ flexed; MCP 40-60◦ flexed.

Results:

Both the modified Kleinert and modified Duran protocols are effective for rehabilitation of flexor tendon injuries, but when used in conjunction they are more efficient and successful.

7. DISCUSSION

This review discusses the important aspects of rehabilitation protocols in flexor tendon management with a particular review of Duran and Kleinert techniques and their combined possible advantages. Various studies suggest that tendon healing, adhesion formation, and functional recovery are enhanced with early mobilization exercise.

Passive mobilization of the tendon using the Duran protocol is preferred for its ease and low rate of rupture, but there is evidence that excessive immobilization can lead to frozen shoulder and loss of tendon glide. In contrast, the Kleinert technique allows active extension of the fingers while passively flexing them. This has been shown to enhance healing of the tendon as well as restoration of motion. This technique does have its merits, but there is also the concern of flexion contractures from this method.

This review incorporates studies that recommend both protocols and propose a change in the technique to allow for movement while avoiding complications of extension.

Functional outcomes tend to be better when a balanced rehabilitation protocol is followed as suggested by the review findings.

Still, some limitations in the literature Kane discovered must be noted. The differences in study method, sample, and other variables make it impossible to draw accurate conclusions. Further, the level of compliance from the patients and the skills of the therapists may affect the results of the rehabilitation program. It is recommended that the next studies focus on unifying the rehabilitation procedures and formulating them into a comprehensive large randomized controlled trial – in order to form the best possible treatment options for patients with flexor tendon injuries.

In summary, rehabilitation is critical for recovery after the suffering of tendon flexor injuries. Both Duran's and Kleinert's techniques for tendon rehabilitation worked, but the combined approach was the most functional. More work must be done in the future to further improve the outcomes for patients.

8. CONCLUSION

Most cases of flexor tendon injury are the result of penetrating trauma. Restoring function, and preventing further injury after repair, is the goal of postoperative rehabilitation. The two principal protocols for rehabilitation of flexion tendon injury are the modified Kleinert and modified Duran techniques. From this study, we conclude that the combined regimen of modified Kleinert and modified Duran techniques is more effective for the rehabilitation of flexor tendon injury than using each technique individually.

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