Repair of Flexor Tendon Injuries of the Hand Using Venous Graft as a Tendon Sheath Substitute

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Abstract

Background: In the work of everyday life, the hand is frequently exposed to injuries that may affect the function. Complex injuries of the hand result in soft tissue damage with loss of function. The main target of surgeons is to avoid the occurrence of post operative adhesions. Better understanding of the pathophysiological nature of tendon healing and continuous evolution of operative technique improves the result. Use of venous graft as a tendon sheath substitute following tendon repair reduce the adhesion formation, improve tendon nourishment, decrease the need for intensive physiotherapy, restore the function and improve the results. Despite this remarkable progress, flexor tendon lesions continue to present a difficulty.

Material and Methods: Twenty patients had tendon injuries of the hand involving different zones, they were recent injured. We use modified Kessler technique for primary repair of acute flexor tendons injuries using the cephalic vein as a tendon sheath substitute.

Results: Evaluation of the results is based on TAM score of the American society for surgery of the hand. The final results were 90% excellent and 10% good, no fair or poor results.

Conclusion: Repair of the flexor tendon injuries using modified Kessler technique using a venous graft as a tendon sheath substitute and early active movement is recommended to provide effective results.

Key Words: Cephalic vein – Repair – Tendon sheath.

Introduction

THE hand was divided into several zones according to classification of Verdan [1,2] (Fig. 1).

Alnat [3,4] classified tendon injuries into type I and type II according to the severity of the injuries and associated lesion as follow:

Type I:
- Complete cut without retraction.
- Cutenous lesion without risk of necrosis.
- No injuries of neurovascular bundle.

Type II A:
- Complete cut with retraction.
- Cutenous lesion without risk of necrosis.
- Associated neurovascular bundle lesion.

Type II B:
- Tendon cut with contused end.
- Possible lesion of dorsal structures.
- Associated fractures.
- Injuries of both neurovascular bundles.

Kleinert [5] established the superiority of primary flexor tendon repair over secondary grafting. The methods of repair and postoperative management varied greatly from surgeon to surgeon.

Applying early post repair motion stress to repaired flexor tendons has been shown to be beneficial for more rapid recovery of tensile strength, fewer adhesion, improved tendon excursion and minimal repair site deformation [6,7].

Fig. (1): Verdan classification of the flexor system.
The ideal end result of tendon repair is full recovery of unrestricted pain free motion and strength, for many reasons, this may be not achieved when full active motion is restricted following tendon repair. The surgeon must determine if the decreased motion is secondary to disruption of the repair, a joint problem, contracture, tendon adhesion, or other problem [8].

The using of venous graft as a tendon sheath substitute following tendon repair is a new technique for managing tendon injury that may improve the result of existing method [9].

This study represents the management of 20 acute flexor tendon injuries with modified Kessler method with venous graft as a tendon sheath substitute and discussing the complications and postoperative management.

Material and Methods

Twenty patients with acute flexor tendon injuries of the hand were included in this study in the period from June 2009 to December 2011 in Beni Suef University and Health Insurance hospitals. There were 5 patients in zone I, 10 patients in zone II, 3 patients in zone III and 2 patients in zone V in 20 fingers. There were 15 males (75%) and 5 females (25%) with average age (29 years) ranged from 18-40 years.

All patients presented with type I and/or type II lesions and operated at the same day of admission. Patients with severe cutaneous lesions of dorsal structures, associated fractures and tendon cut with contused end were excluded from our study. There were 17 injuries of the right hand and 3 injuries of the left hand.

After primary survey, full history taking and detailed clinical examination had been performed with special emphasis on:

- Concomitant life threading injuries.
- Occupational status.
- Dominant hand.
- The nature of the object producing the injury.
- Time lapse between trauma and hospital presentation.
- Site, size and depth of wound.
- Associated bone injuries (X-ray routine).
- Vascular and nerve injury of affected finger.
- Movement of the fingers and hand at the level of wrist, metacarpo-phalangeal and inter-phalangeal joints.

Intra-venous antibiotics and anti titanic serum was used immediately.

Surgical approach:

The surgical approach is in fact:

- The wound itself, extended at both ends by oblique incisions.
- Through debridement and irrigation is carried out, after which an accurate re-evaluation of the injured structures is determined (neurovascular and tendinous injuries).
- For retracted tendon end, we use skin hook for visualization of the tendon ends 8 (40%) or a small catheter beneath the annular pulley for the retracted tendon stump [10,11].
- Refreshment of the tendon ends was carried out in most of the cases (70%).
- The cephalic vein was used as a donor of venous graft in all patients; the required length of the graft needed for repair is 1cm (Fig. 2).
- There were two methods to apply vein graft.

1- If the diameter of the vein is larger than the injured tendon we pass either proximal or distal end of the tendon through the segment of the vein prior to the repair and then sliding the venous segment over the repair site (Fig. 3).

2- If the diameter of the vein is less than the injured tendon the vein graft was preserved in an isotonic saline till the repair is performed then vein graft is incised longitudinally and used as a patch around the repaired site then sutured to itself behind the repaired site converting it into tunnel (Fig. 4).

After application of the vein graft 5.0 polypropylene is used to fix the ends of the graft to tendon sheath proximally and distally.

- Both FDP and FDS were repaired in all zones by modified Kessler technique using 5.0 polypropylene sutures.

Postoperative dorsal slab was applied from elbow to finger tips with the wrist in mid flexion, the MP joint is slightly less than 90° flexion and the IP joints straight for 6 weeks. The exercises consisted of two phases; the first consisted of protected passive motion during the first 3 weeks, while the second consisted of assisted active motion during the second 3 weeks. The splint was removed by the 6th week.
Patients were seen once a week during the first 3 weeks then at the end of 6 th week postoperatively and at the end of 3 months, then with varying degree of frequency according to individual variations. Final assessment was considered one month after return to work with the same level of activity using TAM scoring system of American society for surgeons of the hand (Table 1) [12].

Table (1): TAM scoring system of American society for surgeons of the hand.

<table>
<thead>
<tr>
<th>Grade</th>
<th>TAM score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>100% normal</td>
</tr>
<tr>
<td>Good</td>
<td>75-99% normal</td>
</tr>
<tr>
<td>Fair</td>
<td>50-74% normal</td>
</tr>
<tr>
<td>Poor</td>
<td>Less than 50% normal</td>
</tr>
</tbody>
</table>

Results

Most of the patients aged 18-40 years with mean age 29 years. Most of the patients included in this study were males representing 75% while females representing 25% of all patients. Regarding occupational status, 40% of the patients didn’t need fine movement to perform their work.

Patients who needed fine movements were 12 patients (students 4, carpenters 4, computer operators 2, and accountant 2). Patients who needed no fine movement were 8 patients (farmers 3, housewives 4, and driver 1).

Dominant hand was more commonly injured in 75% of the patients. The causative agent was a knife in 8 patients, saw in 4 patients, glasses in 3 patients and other agents in 5 patients.

We use Strickland formula for evaluation of total active range of motion (TMA) of the fingers. The Strickland formula is a modification of the TMA method, in which MP joints is disregarded and the injured finger is compared to a reference value 175⁰, corresponding to the sum of 100⁰ for PIP and 75⁰ for DIP.

\[
\frac{\text{Active flexion (PIP + DIP)} - \text{Extension deficit (PIP + DIP)}}{175^\circ} \times 10^\circ = \text{X}\%
\]

100% ≥ mTMA ≥ 85% = Excellent
84% ≥ mTMA ≥ 70% = Good
69% ≥ mTMA ≥ 50% = Fair
mTMA <50% = Bad

There were 20 injured finger distributed as 5 in zone I, 10 in zone II, 3 in zone III and 2 in zone V. There were isolated FDP lesions in 8 patients (5 in zone I,3 in other zones) and combined FDP with FDS in 12 patients. There were 19 patients with type I injury and one patient with type II A in zone II (one neurovascular bundle according to Alnat classification).

The ring finger was affected in 40%, the middle finger in 30%, the little finger in 15% and the index finger in 15%. Zone II was the most common site...
of injury where it was injured in 10 patients. Zone I and zone III represents the second most common site of injury, 5 patients and 3 patients respectively. Zone V was the least frequency of injury; affected in only 2 patients. Zone IV was not injured in all patients.

The venous graft was harvested from cephalic vein in all cases and was applied as a segment in 40% (8 patients) and as a patch in 60% (12 patients) of patients. The final results were evaluated according to Strickland evaluation system (Table 2).

We analyzed the different factors which may affect the results such as zone of injury (Table 3), type of injury (Table 4) and tendons involved (Table 5).

Regarding adhesions and range of motion, excellent range of motion achieved in 90% of patients, while good range of motion was achieved in 10% of patients (Figs. 5,6).

**Complications:**

Two patients developed adhesion and contracted scar but good range of motion was achieved and the results were less satisfactory than in other patients. One of the two patients who had adhesions had also infection and surgical debridement was carried out until the sample isolated from the wound was microbiologically negative. No cases of tendon rupture, pulley disruption or joint stiffness were reported in our study. One case with lacerated skin developed infection, contracted scar and limited range of motion.

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**Fig. (5):** A patient with right ring finger injury at zone 2 involving FDP and FDS.

**Fig. (6):** A patient with right index finger injury at zone 3 involving FDP and FDS.
Table (2): The absolute result of the series.

<table>
<thead>
<tr>
<th>Final result</th>
<th>Number of tendon</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>18</td>
<td>90</td>
</tr>
<tr>
<td>Good</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Fair</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Poor</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table (3): Final result according to zone of injury.

<table>
<thead>
<tr>
<th>Zone</th>
<th>Result</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone I</td>
<td>Excellent 4</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Good 1</td>
<td>5</td>
</tr>
<tr>
<td>Zone II</td>
<td>Excellent 9</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>Good 1</td>
<td>5</td>
</tr>
<tr>
<td>Zone III</td>
<td>Excellent 3</td>
<td>15</td>
</tr>
<tr>
<td>Zone V</td>
<td>Excellent 2</td>
<td>10</td>
</tr>
</tbody>
</table>

Table (4): Results according to type of injury.

<table>
<thead>
<tr>
<th>Type of injury</th>
<th>Number of patients</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type I</td>
<td>19</td>
<td>18 excellent 1 good</td>
</tr>
<tr>
<td>Type II</td>
<td>1</td>
<td>1 good</td>
</tr>
</tbody>
</table>

Table (5): The result according to tendons involved.

<table>
<thead>
<tr>
<th>Involved tendon</th>
<th>Number</th>
<th>Results</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isolated FDP</td>
<td>8</td>
<td>8 excellent</td>
<td>40</td>
</tr>
<tr>
<td>Combined FDP &amp; FDS</td>
<td>12</td>
<td>10 excellent 2 good</td>
<td>50</td>
</tr>
</tbody>
</table>

Discussion

It is undisputed nowadays that primary treatment of acute tendon injury is the best method of treatment. With growing awareness of people for seeking medical attention, patients tended to present immediately to emergency unit [13,14].

The results of our study were consistent with many results reported in literature in similar studies. Alonet et al. [4], Earley et al. [15] and Pribaz et al. [16], as 90% (18 out of 20 tendons) of our patients had excellent results and the previous authors had 80% out of 77 tendons, 85% out of 59 tendons and 87% out of 137 tendons respectively had excellent results.

On the other hand Greekmore and Bellinghawisin [17] and Gault [18] had rather poor results (only 12% out of 44 tendons) and (36% out of 116 digits) respectively. Hunge et al. [12] reported 80% excellent results.

Major advances in understanding of intra synovial flexor tendon biology, repair and rehabilitation have been made since 1960, when reports first demonstrate flexor tendon laceration within the fibro-osseous flexor digital sheath could be repaired primarily and rehabilitation could be carried out successfully with excision of lacerated tendon followed by primary tendon grafting. The concept of adhesion free tendon healing has been validated in clinical studies since that time, Lending supported efforts attempting to achieve a reliable technique of primary flexor tendon repair and digital rehabilitation without the inevitable need for later tenolysis [19].

Despite improvement in surgical and rehabilitation technique, peri-tendinous adhesion formation continue to be the most common complication of tendon surgery [20] and the most frequent cause of disability following tendon surgery [21].

The development of peri-tendinous adhesion tethers the healing tendon and wound site to surrounding tissue element and adversely affects functional outcome [22].

Surgical tendon repair using precise non-traumatic techniques, reconstruction of the tendon sheath and early mobilization all are intended to promote intrinsic tendon healing and achieved an improved functional outcome [21].

In our study the predominance of male population is similar to most other studies [23]. The average age in our study was 29 years ranged from 18-40 years. Some studies consider age as an unfavorable factor [24]. Alonet et al. [4] 15-66 years, Pribaz et al. [16] 12-58 years, had a wider range of age and scored more or less the same outcome as our study.

In the current study the zone with the most common difficulty in surgery and most unwanted results was zone II. This conforms with other studies on flexor tendon injuries [3,4,15,24]. The close relation between FDP and FDS within the flexor sheath and the narrow digital canal in addition to the critical nature of the blood supply make the surgery, results and complications a great deal and challenge for surgeon concerned with repair in this zone [24,25].

The presence of combined FDP and FDS lesions is associated with less satisfactory results was confirmed in our study. This fact is widely documented in literature [3-8]. Combined FDP and FDS lesions mark the more aggressive nature of the trauma and entail more surgical manipulation within
the tendon bed and more suture bulk in repair site; all are factors that cause adhesion formation [18,24,26-30].

It was evident in our study that the presence of skin laceration favors worse results and associated with increased incidence of infection. Reported studies [4,24,31] that observed skin laceration as a specific determinant of final outcome showed the same conclusion.

Our use of modified Kessler technique also can forms with the choice of the majority of authors [3,4,24]. The advantage of this technique is its simplicity to apply and the relative minimal suture material within the repair site [3,4].

The most accepted methods of evaluation for fingers are the TMA (total active motion) method recommended in 1967 by the clinical assessment of American society for surgery of the hand and that proposed by Strickland [24,32].

The principle advantage of Strickland evaluation system over the other proposed systems is that it does not Lake MP joint mobility into account. Mc Grauther has shown that MP joint motion depends essentially on intrinsic muscles and that in zone 2 the flexor tendons don’t move on flexing MP joint from 0° up to 60° [10,33].

Moosavi and colleagues [9], studies the use of vein graft as a tendon sheath substitute following flexor tendon repair to assess the range of motion after flexor tendon repair. Excellent result were achieved in 86% of patients, good results in 11 %, fair results in 3% and no poor results. Differences between results of our study and Moosavi’s study may be due to fewer numbers of patients and short term follow-up.

The use of autologus vein graft as a replacement of tendon sheath has many advantages like; it is not expensive, being autologus so not carrying the risk of infection, will not affect the tendon healing like other materials and it is not only used to treat postoperative tendon adhesion but also can be used as a prophylactic procedures in cases of lost tendon sheath in fresh cases [9].

Conclusion:

The repair of flexor tendons of the hand with a vein graft as a tendon sheath substitute showed evident difference and better results than repair of the tendon without repair of tendon sheath. This technique reduces adhesion formation, improve tendon nourishment and decrease the need of intensive physiotherapy. The combination of this technique with early mobilization will add to minimize adhesion and improving the result of tendon repair.

References