

Modalities of extensor tendon repair related to etiological factors and associated injuries

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ABSTRACT

Aim To evaluate modalities of extensor tendons repair of hand and forearm in specific anatomical zones with regard to etiological factors and presence of associated injuries of adjacent anatomical structures.

Methods This cross-sectional study included 279 patients referred for extensor tendon repair of hand and forearm in specific anatomical zones. Available treatment modalities were evaluated concerning etiological factors, anatomical zones, and associated injuries. Statistical significance was analysed in the occurrence of early and late postoperative complications according to anatomical zones.

Results Direct repair of extensor tendon lesions was found to be the most common modality of reconstruction, 230 (93.5%), of which blade injuries were predominant, 120 (48.7%). Direct tendon repair was mostly indicated in Zone VI and Zone III, in 55 (23.9%) and 42 (18.3%) patients, respectively. Statistically, a significant correlation was confirmed between treatment modalities, injuries in specific anatomical zones, and type of etiological factor ($p < 0.0001$). Statistical correlation was confirmed between zones of injuries and the occurrence of early and late complications ($p = 0.002$).

Conclusion Successful postoperative recovery was correlated with the recognition of functional failure in specific zones, assessment of potential associated injuries, and selection of the most optimal modality of reconstruction.

Key words: associated injury, etiologic factors, extensor tendons, tendon repair

INTRODUCTION

The specifics of the extensor tendons are reflected in their superficial anatomical localization, which makes them exposed to a potentially destructive action of various etiological factors (1). Due to the balance of the extensor and flexor system of the hand and forearm, which is necessary for the sophisticated function of the hand, the reconstruction of the extensor tendons in terms of primary reparation, tendon transposition or tenoplasty, is a complex process (2).

In acute hand trauma, treatment can be conservative and surgical, in terms of primary tendon reparation with the approximation of tendon ends, or tendon transposition and tenoplasty, in the case of significant tissue destruction (2).

Multiple etiological factors can lead to a traumatic lesion of the extensor tendons of the hand and forearm (3).

Any trauma of the extensor system requires appropriate surgical evaluation to select the most optimal reconstructive procedure based on an individual reconstruction plan (4).

The anatomical division of the extensor tendons of the hand and forearm into specific zones is a useful means of facilitated evaluation of the extent of the lesion, taking into account the specifics of each zone (5).

Due to its superficial localization, the extensor system is potentially exposed to trauma in all anatomical zones, with a full spectrum of variations of acute and chronic injuries (6), but the evaluation of the extent of the injury is facilitated by classification into anatomical zones, which allows taking into account their specifics and the existence of possible associated injuries of neighboring anatomical structures (7,8) which are most often the consequence of the destructive action of certain etiological agents, with multilevel lesions and difficult functional recovery (9).

Modern concepts of hand surgery go in the direction of rapid recovery and satisfactory postoperative functionality because inadequately treated and unrecognized lesions lead to permanent disability, and potential complications (10). The most optimal treatment is the one that enables the best functional result, the direct reparation is most optimal whenever local conditions allow it, which is a consequence of the relative simplicity of the procedure itself (11).

Certain anatomical zones were related to better postoperative results regardless of treatment modality (12).

Reconstruction of extensor tendons must be seen as a reconstructive challenge (13), because the type of primary trauma can potentially completely exclude the possibility of direct tendon repair and may represent an absolute indication for tendon transfer or tendon grafts, which is related to the etiological aspect of the injury (14) where the choice of donor's motor unit or tendon graft is crucial for the final functional outcome (13). This is particularly important in complex upper extremity trauma (15).

Due to anatomical complexity, the focus of reconstruction has previously been directed to the flexor tendons of the hand, but, as presented by Amirharajah et al. new concepts of acute hand trauma emphasize the timely reconstruction of extensor tendons (16).

To optimize the treatment, it is necessary to establish clinical guidelines to improve the postoperative functional results after conservative and operative treatment (17).

The aim of this study was to evaluate the relationship between the etiological factor and the resulting tendon destruction as clinical guidelines in the selection of surgical modality in specific anatomical zones of the extensor system of the hand and forearm, as well as the occurrence of associated injuries of adjacent anatomical structures and postoperative complications in anatomical zones, which are the result of tissue destruction caused by etiological factors.

PATIENTS AND METHODS

Patients and study design

The observational, cross-sectional, controlled study involved 279 patients who were diagnosed and treated with extensor tendon injuries of hand and forearm in different zones at the Clinic of Reconstructive and Plastic Surgery, Clinical Centre of the University of Sarajevo, during the period 2014-2019. All patients underwent clinical examination for functional failure and standard hand X-ray for assessment of associated bone injuries, as a diagnostic method of choice. The patients previously treated in other hospital centres and the patients with unrecognized extensor lesions were excluded from this study.

All patients signed a written consent for inclusion in the study.

The study was approved by the Research Ethics Committee of the Clinical Centre of the University of Sarajevo

Methods

According to the level of the lesion, extensor tendons were classified into anatomical zones (1): Zone I – distal interphalangeal joint, Zone II - middle phalanx, Zone III – proximal interphalangeal joint, Zone IV - proximal phalanx, Zone V - metacarpophalangeal joint, Zone VI - metacarpal level, Zone VII - dorsal retinaculum, Zone VIII - distal forearm, and Zone IX - mid and proximal forearm. Available treatment modalities (direct tendon repair, tenoplasty, tendon transposition or conservative treatment) were chosen according to anatomical zones, different etiological factors (a blade, circular sawing machine, axe, and glass), and associated injuries (bones-extensor tendons, flexor-extensor tendons, peripheral nerves-extensor tendons) of the adjacent anatomical structures. The distribution of early and late postoperative complications by anatomical zones was analysed.

Statistical analysis

Descriptive processing of statistical data was carried out for the significance of etiological factors on the selection of reconstruction modalities, as well as the appearance of combined lesions of adjacent anatomical structures and postoperative complications in specific zones. The data were analysed using χ^2 and Fischer test. The $p < 0.05$ was used as statistically significant.

RESULTS

The study included 279 patients (233 males and 46 females). Mean age of male patients was 39 (range from 28 to 50 years), of female 35 (range from 27 to 50 years) ($p=0.969$).

A type of etiological factor, due to the different degrees of tissue destruction, was determined as the most optimal modality of treatment. Direct tendon reparation was the most common treatment modality, in 230 (82.43%) patients, of which 120 (43%) had blade injury, and 69 (24.73%) circular saw machine injury; in one (0.36%) patient with persistent deformity after the removal of splint immobilization, direct tendon repair was indicated. Tendon transposition, a modality of recon-

struction based on the use of an available donor tendon unit, was indicated in 13 (4.66%) patients, of which it was most often indicated in the circular saw machine injury, in nine (3.23%) patients. Tenoplasty, based on the use of free tendon grafts, was indicated in three (1.08%) patients, all for circular saw machine injuries due to loss of tissue continuity. Closed injuries, related to the loss of tendon continuity at the level of the distal phalangeal joint ("mallet finger"), were mostly treated conservatively by six-week splint immobilization, in 33 (11.83%) patients (Table 1) ($p < 0.0001$).

Table 1. Distribution of tendon destruction in 279 patients caused by different etiological factors according to the treatment modality

Etiology of destruction	No (%) of patients			
	Direct repair	Tenoplasty	Tendon transposition	Conservative treatment
Blade	120 (43)	0	0	0
Circular sawing machine	69 (24.73)	3 (1.08)	9 (3.23)	0
Axe	30 (10.75)	0	4 (1.43)	0
Glass	10 (3.58)	0	0	0
Closed injury	1 (0.36)	0	0	33 (11.83)
Total	230 (82.43)	3 (1.08)	13 (4.66)	33 (11.83)

Although different etiological factor determines reconstruction modalities, certain types of reconstruction were more represented than others in anatomical zones ($p < 0.0001$). Zone I, associated with injury of extensor aponeurosis at the level of the distal interphalangeal joint, was successfully treated mostly with conservative six-week immobilization, in 33 (82.5%) patients. The direct repair was the most common modality of reconstruction. All injuries in Zone II, 30 (10.75%), were treated by direct reparation. In other anatomical zones, the frequency of direct tendon repair was variable, from 10 (3.58%) in Zone I to 55 (19.7%) in Zone VI (19.7%). Tendon transposition was most common in Zone IV, in nine (3.22%) patients. Tenoplasty was the least represented operative modality, in one (0.36%) patient in each Zone V and VI (Figure 1) ($p < 0.0001$).

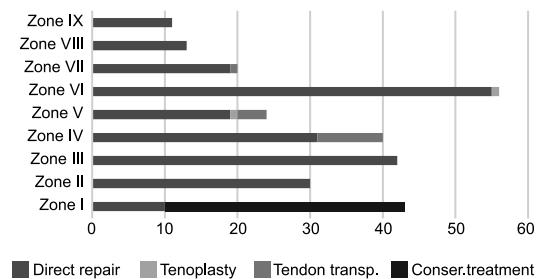


Figure 1. Treatment modalities in anatomical zones

Associated injuries of the adjacent structures were differently distributed in anatomical zones ($p < 0.0001$). In Zone IV associated bone-extensor tendons injuries were relatively common, 23 (8.24%). The higher possibility of the presence of this type of associated injuries was found in Zones V and VI, in 15 (5.37%), and 21 (7.53%) patients, respectively. Associated injuries of the extensor tendons with flexor tendons and peripheral nerves were presented in smaller percentages. Associated extensor-flexor tendons injuries were presented in smaller percentages, with one (0.36%) in each Zone IV, VI and VII, and two (0.72%) in Zone V. Associated peripheral nerves-extensor tendons injuries were minimally represented, one (0.36%) in each Zone IV-VI (Table 2) ($p < 0.0001$).

Table 2. Types of associated injuries according to anatomical zones

Anatomical zone	No (%) of patients with extensor tendon			
	Bones-extensor	Flexor-extensor	Peripheral nerves-extensor	Isolated extensor
Zone I	0	0	0	43 (15.4)
Zone II	0	0	0	30 (10.7)
Zone III	0	0	0	42 (15.1)
Zone IV	23 (8.24)	1 (0.36)	0	16 (5.73)
Zone V	15 (5.37)	2 (0.72)	1 (0.36)	6 (2.15)
Zone VI	21 (7.53)	1 (0.36)	1 (0.36)	33 (11.8)
Zone VII	1 (0.36)	1 (0.35)	1 (0.36)	17 (6.09)
Zone VIII	0	0	0	13 (4.66)
Zone IX	0	0	0	11 (3.94)
Total	60 (21.5)	5 (1.8)	3 (1.08)	211 (75.62)

Two types of early complications were found in our study group, tendon rupture, in two (0.72%) patients in each Zone IV and VI, and infection in eight (2.87%) patients in each Zone IV, VI, and VII. Contractures were represented in two anatomical zones, seven (2.5%) in each Zone III and VI ($p = 0.002$) (Table 3).

Table 3. Distribution of early and late complications according to anatomical zones

Anatomical zone	No (%) of patients with/without complication			
	Rupture	Infection	Contracture	Without complications
I	0	0	0	43 (15.4)
II	0	0	0	30 (10.8)
III	0	0	3 (1.07)	39 (13.9)
IV	1 (0.36)	3 (1.07)	0	36 (12.9)
V	0	0	0	24 (1.43)
VI	1 (0.36)	2 (0.72)	4 (1.43)	49 (17.6)
VII	0	3 (1.07)	0	17 (6.09)
VIII	0	0	0	13 (4.66)
IX	0	0	0	11 (3.94)
Total	2 (0.72)	8 (2.87)	7 (2.5)	262 (93.91)

DISCUSSION

The results of this study showed that direct repair of the extensor tendon mechanism of the hand and forearm has been the most common modality of reconstruction, regardless of the etiological factor and the anatomical zone of the injury. Isolated injuries were the most common in all zones, while combined extensor lesions with bone structures were the most common type of associated injury due to close anatomical localization. Associated injuries with flexor tendons, and peripheral nerves were present in a small number of cases, with a specific distribution according to the corresponding zones, but also as a consequence of stronger destruction of specific etiological factors. The distribution of early and late complications was without a clear clinical correlation with injury zones.

The etiological factors with the resulting lesions of the extensor tendons are numerous, mostly related to work activity, which was defined in 2010 as the Standard Occupational Classification structure. Injuries inflicted by machines at work and home are very common in everyday practice. The type of etiological factor determines the so-called "injury pattern" and the type of reconstructive procedure, although primary tendon repair is preferred due to faster postoperative recovery (18).

The type of extensor reparation is not correlated with the anatomical zones of injury, unlike etiological factors because certain etiological factors resulted in a greater degree of tissue destruction and prevented direct and/or primary reparation. Primary reparation, as functionally and reconstructively the most acceptable treatment modality, is preferred in all anatomical zones (19).

Injuries of the extensor tendons can be combined with a lesion of bone structures, neurovascular elements, flexor tendons, and soft tissue covering, which makes postoperative recovery and the functional outcome more complex. Associated extensor-flexor tendon and peripheral nerve-extensor tendon injuries represent the consequence of extensive tissue destruction. The proximity of extensor tendons with phalangeal and metacarpal bones makes this type of associated injury more common despite the absence of significant tissue destruction. Associated injuries of extensor tendons and bone structures are most

common due to close anatomical contact and high probability of combined lesions (20).

Postoperative treatment is very important to prevent potential complications, which requires careful postoperative monitoring by injury zones. The low prevalence of early and late complications is the result of the implementation of antibiotic prophylaxis protocols, postoperative mobilization, and active cooperation with the patient (5).

The study showed the importance of clinical assessment of extensor tendon injury to the aetiology, the level of injury classified into anatomical zones and to the treatment modality, which is the ultimate treatment protocol, especially considering the synergy with flexor tendons, as complex musculoskeletal systems, necessary for the sophisticated hand function (11).

Intra and postoperative protocols are still subjects of debates, but the importance of the appropriate assessment of the lesion extent and its anatomical level is crucial for the quality of postoperative recovery (21). Different variations of the treatment protocol depending on the lesion zone have been presented in the literature, but in clinical practice, it has been confirmed that a unique approach to the treatment is applicable in all zones (22). New concepts of early active postoperative mobilization have been replaced by new concepts of early active mobilization, which has been presented in

a study by Meritt et al., thereby significantly improving postoperative functionality (23).

In this study we confirmed that the direct repair of the tendon mechanism was the most optimal modality of reconstruction in all anatomical zones of injury and that the etiological factors were directly related to the degree of destruction. The presence of associated injuries does not affect the reconstruction modalities selection. We have proven the possibility of direct repair of the extensor tendon on all anatomical zones, regardless of the associated injuries, in all cases of the direct tendon approximation.

In conclusion, a lesion of the extensor tendons of the forearm and hand requires careful clinical assessment and recognition of functional failure. The possibility of the existence of associated injuries requires the adequate clinical assessment of functional failure and proper treatment to promote quality and rapid recovery. The implementation of clinical guidelines enables appropriate clinical assessment consistent with the modern concept of hand surgery.

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TRANSPARENCY DECLARATION

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