

# The modalities of flexor tendon reconstruction of the hand correlated with the level of injury and etiologic factor

Biomedicine and Surgery

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## ABSTRACT

**AIM:** Successful flexor tendon reconstruction is inevitably connected with local tissue equilibrium and satisfactory joint mobility. The etiologic factors and levels of the flexor tendon injuries determine the selection of the available operative modalities. Postoperative physical therapy prevents contracture formations and has influence on the definitive postoperative outcome.

**METHODS:** We have evaluated postoperative results after flexor tendon repair in 116 cases during five-year period. We have used Microsoft Excel program and IBM statistics SPSSv 21 or 22.

**RESULTS:** Noticeable correlation between the type of etiologic factor and the modality of flexor tendon repair has been evaluated. The flexor tendon injuries caused by sharp objects (58.62%) had been treated mostly by primary repair (82.4%). Extensive destruction of tendon tissue caused by the other types of the etiologic agents have represented the indication for tenoplasty, which have been applied mainly in Zone II (40.4%), the most frequently zone of tendon injury in our research (40.52%), with primary and secondary repair.

**CONCLUSION:** There is a very clear correlation between the etiologic factor and the level of the flexor tendon injury with selection of the appropriate operative modality.

**KEYWORDS:** flexor tendon; injury; reconstruction modality;

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## INTRODUCTION

Flexor tendon injuries are significant segment of the hand trauma. Unrecognizable functional deficit associated with flexor tendon injuries and inappropriate treatment could lead patient to permanent disability. Improved methods of primary flexor tendon repair have diminished the need for tendon reconstruction. Nonetheless, reconstruction remains an option for neglected digital flexor tendon lacerations and for failed flexor tendon repair in patients who have a supple, sensate finger and who are able to comply with an extensive rehabilitation program. Injuries to the flexor tendons remain among the most difficult problems in hand surgery.

Historically, lacerations to the intrasynovial portion of the flexor tendons were thought to be unsuitable for primary repair. Despite continuing

advances in our knowledge of flexor tendon biology, repair, and rehabilitation, good results following primary repair of flexor tendons of the hand remain challenging to achieve (1). Injuries to the flexor tendons remain among the most difficult problems in hand surgery. Preoperative and intraoperative findings dictate whether a one-stage or two-stage procedure is appropriate (2). Primary surgical repair results in better functional outcome compared to secondary repair or tendon graft surgery (3). Flexor tendon injuries are seen commonly, while the protocols of management are still subject of debate. The advances in suture techniques, better understanding of the tendon morphology and its biomechanics have resulted in better postoperative outcomes (4). Flexor tendon injuries can be isolated or combined with adjacent anatomical structures. The

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flexor tendon reconstruction have to be considered regarding to relevant factors such as the timing of the surgical procedure, the adequate evaluation of the concomitant injuries of the adjacent structures, the quality of the soft tissue cover, the neurovascular status of the hand and the functional interphalangeal joints. Despite all the improvements of the surgical techniques of the flexor tendon repair, the functional postoperative results could be compromised with many potential complications. The early possible postoperative complication such as infections, necrosis of the soft tissue cover, the insufficient circulation and the potential late complications related with the tendon's adhesions and the joint contracture have important and inevitable influence on the final functional results (5,6).

## MATERIALS AND METHODS

We have evaluated the correlation between indicated operative modalities of flexor tendon reconstruction with the level and etiologic factor in 116 cases, treated at the Clinic for reconstructive and plastic surgery University Clinical Center of University of Sarajevo, for the period 2010-2015. Since the Kolmogorov-Smirnov test have proved that the variable of the etiological factors, operative modalities and level of the injuries had not meet the criteria of the normal distribution, and considering a relatively small numbers of samples, the testing of the difference have been made through non-parametric Kruskal-Wallis test. The test results with  $p < 0.05$  or the confidence level of 95% have been considered statistically significant. The analysis has been carried out with Microsoft Excel program and IBM statistics SPSS v21 or 22.0.

## RESULTS

There is noticeable difference between the specific etiological factors (Figure 1). The sharp objects have been the most common etiological factors (68 or 58.62%), followed by injuries with industrial machines (25 or 21.55%). The other etiological factors have been represented in the smaller percentages, such as explosive devices (1 or 0.86%), the human and animal bites (2 or 1.72%), contusion wounds (3 or 2.58%). The unknown etiological factors of the flexor tendon injuries have been represented on the Figure 1 as a percentage of 14.66%.

During the five-year followed period no tendon transposition has been undertaken as the type of the flexor tendon reconstruction (Figure 2). The primary reparation or tenorrhaphy has been performed in the majority of cases (82 cases; 70.69%), followed by

secondary reparation or tenorrhaphy (9 cases; 7.76%) and tenoplasty in the more complicated cases, with no possibility of the direct tendon approximation (25 cases; 21.55%).

The primary tenorrhaphy has been applied for flexor tendon reconstruction after injuries with sharp objects (56 cases; 82.4%) and industrial machines (22 cases; 88%) in the high percentage of cases (Figure 3). All the other cases with the other different types of the etiological factors have been treated by tenoplasty as the best options with no possibility of the direct tendon approximation (5 cases; 83%). The statistical analysis has showed that there was a significant difference ( $p < 0.05$ ).

The most of the flexor tendon injuries in Zone I (Figure 4) have been operated by the primary tenorrhaphy (4 cases; 50%) and by the secondary tenorrhaphy (4 cases; 50%). The primary tenorrhaphy has been applied in the most of the primary reconstruction in Zone II (27 cases; 57.40%). In all cases with no possibility of the direct approximation of severed tendon, we have used the tenoplasty as the best and recommended option (19 cases; 40.4%). Only in 1 case we have applied the secondary tenorrhaphy as operative modality in Zone II (2.1%). The primary tenorrhaphy has been applied in the most of the cases in the Zone III (3 cases, 75.9%), Zone IV (6 cases, 85.70%) and Zone V (23 cases; 92%). The secondary tenorrhaphy has been applied in varying percentages in proximal zones, such as Zone III (3 cases; 10.3%) and Zone V (23 cases; 92%). Tenoplasty has also been applied in varying percentages according to the specific zones, Zone III (4 cases; 13.8%), Zone IV (1 case; 14.3%) and Zone V (1 case; 14.3%). The methods of the flexor tendon reconstruction have been adjusted to the various levels of the injury. This has been evaluated through analysis of the differences in the application of the reconstruction modalities, what has been showed through statistical significance ( $p < 0.05$ ).

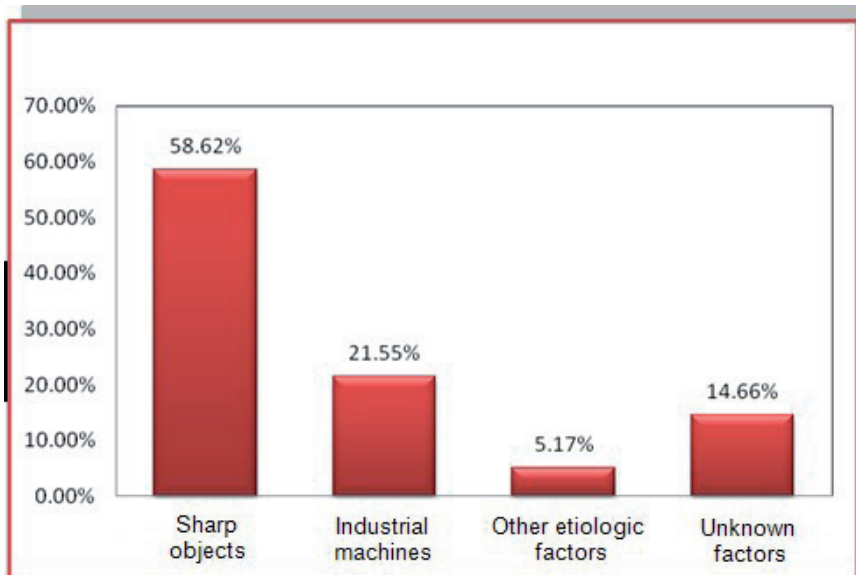


Figure 1 . Etiologic factors of the flexor tendon injuries.

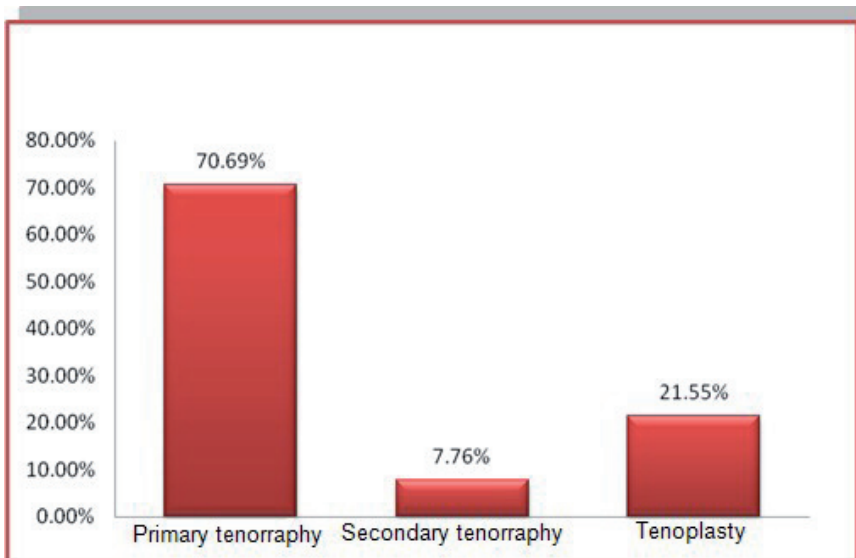


Figure 2 . The applied modalities of the flexor tendon reconstruction.

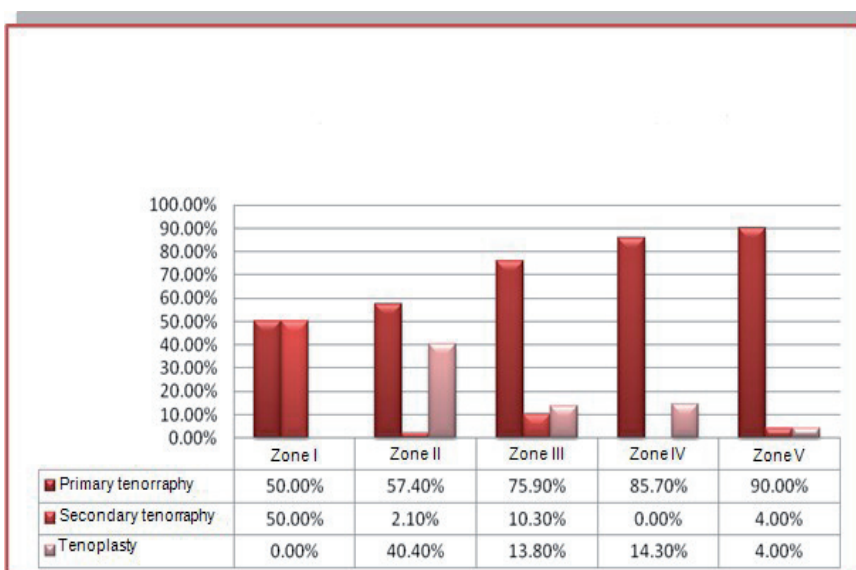
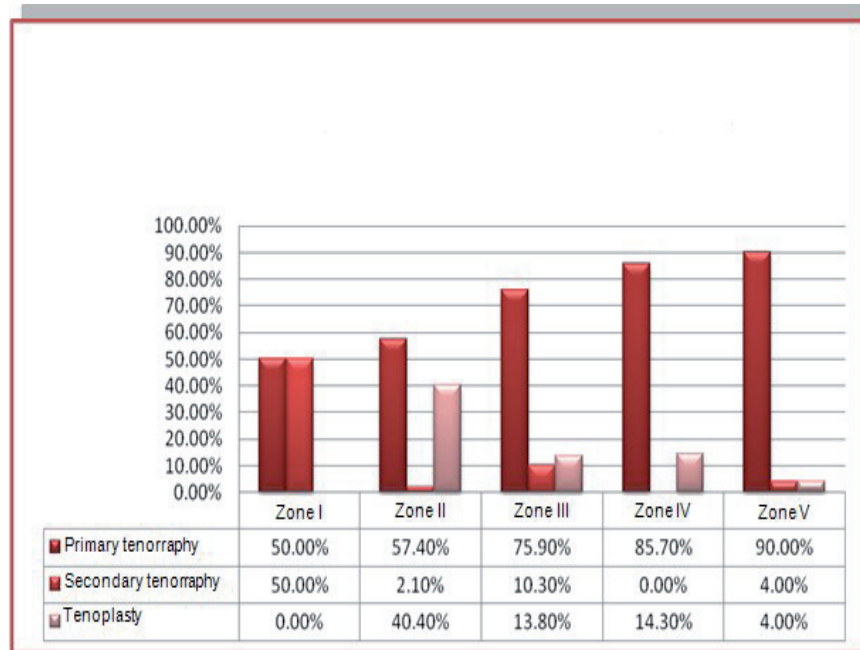


Figure 3 . The modality of the flexor tendon reconstruction is correlated with etiologic factors (2=5.451; df=2; p=0.001).



**Figure 4.** The modality of flexor tendon reconstruction is correlated with the level of injury ( $\chi^2=12.091$ ;  $df=2$ ;  $p=0.002$ ).

## DISCUSSION

Etiologic factors with resulting sharp edges of severed tendon represents indication for the primary reparation. The early reconstruction does not necessarily mean better functional outcome. Different etiologic factors caused the flexor tendon injuries in the Zone I. In the works of Bynum and Gilbert (1988), the common causes of the flexor tendon injuries at the distal phalanx level have been various wounds and fractures of the distal phalanx with avulsion of tendon insertion. Thereby, the tendon insertion could be torn off with or without the bone fragment (7). On this basis, we can distinguish the three types of flexor tendon injury in this zone:

Type I- the proximal end of the tendon is retracting towards the palmar aspect of the hand, which represents the indication for the immediate reconstruction to prevent functional deficits. According to Lubahn and Hood (1988), this type of the flexor tendon injury has been rare (8).

Type II- the significantly easier type of injury for the reconstruction. Defines the retraction of the tendon to the tendon chiasm. It may or it may not contain the bone fragment. Unlike the Type I injuries, the vascularization is intact, what yields the good postoperative results during the timely reconstruction. According to Lubahn and Hood this type of injury has been the most common.

Type III - characterized by the avulsion of the bigger bone fragment together with tendon insertion retracted to pulley A4. Rarely, tendon insertion can be separated from the bone fragment and retracted to the palmar aspect of the hand.

Reconstruction can be done by Kirschner wires or with little osteosynthetic screws (9). According to the data from the literature, the primary reconstruction was preferred in Zone I. In our research this type of reconstruction has been possible in half of the cases in correlation to the type of etiologic factor. The flexor tendon reconstruction in Zone II (no man`s land) is associated with potentially worst functional results due to the presence of the fibroosseal sheath difficult to reconstruct. The following are the different options of treatment: a) repair of the flexor digitorum profundus (FDP) tendon only with debridement of the flexor digitorum superficialis (FDS) stump; b) repair of both tendons; or d) repair of FDP with repair of one slip of FDS tendon; e) two-phase tendon reconstruction with silastic rod. Repair of both tendons in Zone II is ideal but may be technically demanding.

The indications of secondary tendon reconstruction have decreased as the results of primary reconstruction have improved. The indications for secondary tendon reconstruction are: failed primary repair, neglected injuries, segmental tendon loss and complicated injuries (4). Tenoplasty as modality of reconstruction was the most often applied in Zone II according to the data from our research, which has been consistent with recommended modalities of reconstruction in the literature (10).

We have evaluated a very clear correlation between the time of the flexor tendon reconstruction and the type of etiologic factor. The assessment of possible combined injuries of the adjacent anatomical structures very important and recommended, with



the estimation of the neurocirculatory status. The extensive injuries with possible soft tissue defects represent the contraindication for the primary reconstruction. Unrecognized lesions of the flexor tendons are mainly indication for the secondary reparation in all cases with no possibility of the direct approximation. The tenoplasty is the recommended modality of the flexor tendon reconstruction in Zone II considering potentially the worst functional postoperative results. The potential problem of the flexor tendon reconstruction in the Zone III, IV and V are adjacent anatomical structures, which are in close contact, so that the isolated injuries of the flexor tendon were rare (11). The modality of the reconstruction is also correlated with the etiologic factor and the timing of the reconstruction.

## CONCLUSION

The multiple etiologic factors with resulting flexor tendon injuries determine the time and modality of the reconstruction. The most optimal modality of reconstruction is a primary one, preferred in the all zones, considering the tissue equilibrium. The expecting myostatic contraction after flexor injury, which inevitably occurs after tendon lesion, leads to the impossibility of the direct surgical approximation during the secondary reparation. It has been always indicated in the case of unrecognized injury, tendon rupture after primary reparation or in the all cases of the combined injury when the general condition of the patient represents the contraindication for the surgical treatment. The primary reparation is always associated with a smaller number of the potential complications, with no time for the development of the myostatic contraction. The satisfactory functional recovery is very possible. The secondary reparation or tendon transposition are correlated with higher degree of the functional sequelae. During the evaluation of the injury, it is very important to take into account all mentioned factors and their resulting effects to the final postoperative recovery. The primary reparation of the flexor tendons has been preferred in our research in all cases where local tissue findings and mechanism of injury enable its selection. Adequate assessment of the functional outage implies taking into account the type of etiologic factor, the level of injury, lesions of the adjacent anatomical structures and existence of associated life-threatening injuries. Every postponed reconstruction can be compromised by potentially periarticular scarification, which adversely affects the functional outcome.

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