Evaluation and Functional Assessment of Flexor Tendon Repair in the Hand

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Key words. Hand trauma ; flexor tendon repair ; flexor muscle function.

Abstract. Seventeen patients with 28 flexor tendon injuries were examined after tendon repair. The current most frequently used evaluation systems, including grip and pinch strength, were compared with functional outcome as assessed by a questionnaire, evaluating Disabilities of Arm, Shoulder and Hand (DASH). Good correlation was found between Total Active Motion (TAM) and the Original Strickland test (kappa = 0.85), however with reduced categories. Only limited correlation was found between the DASH-score and TAM (r = -0.33) as well as between the DASH-score and pinch strength (r = -0.35). We suggest reporting the average Range of Motion (ROM) of the complete finger as a percentage of the contralateral finger, instead of reporting the classified result, and to include assessment of pinch strength. It would be very useful to have an accurate functional outcome assessment, but DASH proves to be insufficiently sensitive.

Table I

<table>
<thead>
<tr>
<th>Score</th>
<th>TAM evaluation system of the ASSH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>Normal</td>
</tr>
<tr>
<td>Good</td>
<td>&gt; 75</td>
</tr>
<tr>
<td>Fair</td>
<td>50-75</td>
</tr>
<tr>
<td>Poor</td>
<td>&lt; 50</td>
</tr>
<tr>
<td>Worse</td>
<td>&lt; pre-operative</td>
</tr>
</tbody>
</table>

TAM = total active flexion – total extension deficit (MCP, PIP, DIP)  
\% = TAM of the injured finger / TAM of the contralateral finger.

Table II

Strickland’s evaluation systems

<table>
<thead>
<tr>
<th>Score</th>
<th>Original Strickland %</th>
<th>Adjusted Strickland %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>85-100</td>
<td>75-100</td>
</tr>
<tr>
<td>Good</td>
<td>70-84</td>
<td>50-74</td>
</tr>
<tr>
<td>Fair</td>
<td>50-69</td>
<td>24-49</td>
</tr>
<tr>
<td>Poor</td>
<td>&lt; 50</td>
<td>0-24</td>
</tr>
</tbody>
</table>

Strickland = (active flexion PIP + DIP) – (extension deficit PIP + DIP) · 100%

Introduction

Flexor tendon injuries continue to be disabling diseases. New techniques such as closure of the tendon sheath and multiple strand repair with early active mobilisation are thought to induce better results and should therefore be properly evaluated. However, despite many efforts to reach consensus, many different evaluation systems continue to be used, making any comparison between obtained results impossible. Most investigators only use an anatomical evaluation system, measuring the range of motion (ROM) of the injured finger. These results are then classified according to different protocols, such as Total Active Motion (TAM) (1), proposed by the American Society for Surgery of the Hand (ASSH) (Table I), and the methods of Strickland (2, 3) (Table II). Moreover, the most commonly used systems have never been tested for their validity (does the test measure what it is supposed to measure ?) or their reliability (is the test reproducible ?). Validity can only be tested directly by comparing the test to a golden standard, which is not available. However, validity statements may be made by comparing the test results with the functional results as assessed by questionnaires.

It seems likely that the result of a flexor tendon repair is not only dependent on the finger’s ROM, but also on strength, pain and sensibility. It has been established that strength in the hand and finger are significantly reduced after flexor tendon repair and that this causes disability (4-9). However, no reports were found of functional questionnaires being used to evaluate the results of flexor tendon repair. The question arises therefore, which parameters accurately reflect the functionality of the patient’s hand after flexor tendon repair.

The purpose of this study was to compare a functional outcome score with the current most frequently used anatomical evaluation systems and with grip and pinch strength of the injured hand. To assess functional outcome, the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire (10) was chosen. This test was
recently developed and extensively validated (11-18). It proved to be useful in a number of other disabling conditions of the hand (Table III).

Materials and Methods

A consecutive series of 35 patients who underwent flexor tendon repair in any zone in any finger except for thumbs, between 1992 and 1999 in the Academic Surgical Centre Stuivenberg in Antwerp, was contacted by mail or telephone. Twenty-two patients agreed to participate in a follow-up examination. Exclusion criteria were serious joint damage, injury of the contralateral hand making comparison impossible and serious injury of the same hand inflicted on another occasion. Following these criteria, five subjects had to be excluded, leaving 17 patients for evaluation, representing 28 fingers with flexor tendon injury. The average age of these patients was 32 years (range 15-53) and the average time after operation was 40 months (range 12-89). Following the classical classification, 16 injuries occurred in zone 2, 10 in zone 5, 1 in zone 1 and 1 in zone 3 (Fig. 1). Twelve fingers had a flexor digitorum profundus (FDP) and a flexor digitorum superficialis (FDS) injury, 10 only an FDP injury and 6 only an FDS injury.

Flexor tendon repair was performed according to the technique of Tsuge (19) using a 4/0 polydioxanone (PDS) loop for the core suture and a 5/0 PDS for the epitendinous running suture. Postoperatively, the Kleinert passive mobilisation regimen (20) was applied. Follow-up examination included measurement of the range of motion, grip strength, pinch strength and the DASH questionnaire. The same investigator performed all measurements. The range of motion of the injured and the contralateral finger was measured using a metal finger goniometer. The angles of the metacarpophalangeal (MCP), proximal interphalangeal (PIP) and distal interphalangeal (DIP) joints were measured in maximum active flexion and extension, with the forearm and the wrist in neutral position. Hyperextension was considered abnormal and noted as 0° extension deficit (1). The TAM and both Strickland classification systems were applied (Tables I and II).

Grip strength was measured using a Martin Vigorometer with a medium size bulb. The procedure recommended by the American Society of Hand Therapists was followed (21). The patient was positioned in a chair without elbow-rest opposite the investigator. The shoulder was held in adduction, the elbow in 90° flexion and the forearm and wrist in neutral position. It was explained to the patient how to hold the instrument and to push as hard as possible when told to do so. While pushing, the patient was verbally encouraged to try harder. Both hands were measured alternately, without resting time, until both were measured three times. The average strength of these three measurements was calculated (21). The normal grip strength was predicted from the normal hand. For right hand-dominant individuals the 10%-rule was applied and for left hand-dominant individuals the grip strength was assumed to be the same in both hands (22).

Pinch strength was measured using a Jamar Pinch Gauge. The tip pinch was measured, which is the strength between the pulpa of the involved finger and the pulpa of the thumb (21). The same procedure was followed as in grip strength measurements. For measurement of the tip pinch the patient was asked to bend the other fingers next to the instrument. In this way the FDP-function was maximally included in the strength measurement and the patient was unable to help the injured finger by pushing another finger along (23).
Pinch strength in the injured finger and the same contralateral finger was measured alternately. The average of three measurements was calculated. Normal pinch strength was assumed to be equal to the pinch strength in the normal contralateral finger (24).

A DASH-questionnaire similar to that of the American Academy of Orthopaedic Surgeons (www.aaos.org) was used and translated into Dutch. Questions were asked orally. Scores, ranging from 30 to 150 points, were converted using the formula \( \frac{(\text{score} - 30)}{1.20} \) to a score of 0 to 100. A score of 0 means no difficulties in daily living and a score of 100 means maximum difficulties in performing tasks of daily living.

Statistical Analysis

The SPSS 10.0 statistical programme was used. When normal distribution of the differences between pairs was present, paired Student t-tests were performed. A difference was considered significant when \( p \leq 0.05 \).

To compare the anatomical evaluation systems, a Kappa test of association was used. However, to perform this test no cells could be empty, therefore the cells had to be reduced. The excellent and good results were added to form one group and the fair and poor results formed another group. This reduces the data, but since generally only combined excellent and good results are reported, it will still give a useful measure.

To compare functional with anatomical results, the average DASH-score for each category was calculated and the differences tested with a One-Way ANOVA. Also the Pearson Correlation Coefficient was calculated between DASH-scores and anatomical results as a percentage of the contralateral hand. To compare functional results with results in strength the Pearson Correlation Coefficient was calculated between the DASH-score and the percentage of the contralateral pinch strength. When more than one finger was involved, the average score for one hand was calculated.

Results

Total Active Motion of the injured finger averaged 81.8% ± 14.3SD of the contralateral hand (\( p < 0.0005 \)). The Strickland compared with the measured value of the contralateral hand averaged 73.5% ± 23.8SD (\( p < 0.0005 \)). Results classified according to the three cited systems are shown in Table IV, whereby the Strickland of the injured hand was compared with a value of 175°.

The level of agreement between the various measurements is shown in Table V. Good agreement is reached when a Kappa rate of more than 0.75 is obtained (25), while a rate of 0.4 to 0.75 represents a fair agreement between tests. Only between the TAM and the Original Strickland did we find a good level of agreement. These results pertain to the reduced categories in which excellent and good results are summed.

The average grip strength as a percentage of the predicted value was 79.6% ± 19.8SD (\( p < 0.0005 \)). When calculated as a percentage of the grip strength of the contralateral hand the average was 80.1% ± 18.6SD (\( p < 0.0005 \)). The average tip pinch as a percentage of the contralateral finger was 77.7% ± 27.0SD (\( p < 0.0005 \)).

The average DASH-score was 8.5 ± 7.0SD (range 0-20.8). No significant differences were found between the average DASH-scores by category of the TAM, Original Strickland or Adjusted Strickland. There was a small correlation between the DASH-score and the TAM in percentage (\( r = -0.33 \)) and no correlation between the DASH-score and the Strickland in percentage (\( r = -0.01 \)). Between the DASH-score and tip pinch there was also a small correlation (\( r = -0.35 \)), while it was absent between the DASH-score and grip strength (\( r = -0.12 \)).
Discussion

Comparing different studies in the literature concerning flexor tendon repair is very difficult, if not impossible, not least because of the different evaluation systems used. Moreover, there are many variables interfering with the results, such as nerve injury, vascular damage, whether or not the injury is in the dominant hand, which finger was injured, if more than one finger is injured, etc. Selection of patients should be very strict, taking into account these factors, but this will only be possible in very large centres. The evaluation time since the operation is also an important variable. The study of May and Silfverskiold (26) is the only prospective study that measured the change in ROM repeatedly at set moments. They showed that the ROM mostly improves over the first six months and that a steady-state is reached at about 12 months. For this reason we examined our patients at least 12 months after operation. Earlier evaluation will bias results.

Studying different injured fingers in one hand can also lead to statistical difficulties as it did in our group. We chose to average results of different fingers. An argument against this could be that the worst result should be taken. We found that the worst result is often the little finger, which is also the least important finger in hand function, both in strength and in grip. The result in the little finger is worse because it is easier to avoid using this finger than it is to avoid using an index finger. Therefore it does not seem sensible to use the result in this finger to compare with the result in functionality of the entire hand. The ideal situation would be to select only those hands with an isolated index or middle finger for this study, but that would mean much more clinical material is needed.

Only between the TAM and the Original Strickland was there a good level of agreement in the summated group yielding excellent and good results. However, TAM still reached 12% more in this group than the Original Strickland. In a comparable study of Jansen et al. (27), TAM was not included in their statistical analysis because no numerical definition of the category ‘excellent’ was provided. We interpreted ‘normal’ as being 100%, as do most authors. Applying the Kappa statistic in our setting makes no difference since the excellent and good categories were summated.

Only a small correlation could be found between the DASH-score and TAM, but there was no correlation between the DASH-score and the classification in categories. This could be due to the lack of sensitivity of the DASH-score in flexor tendon repair. The average score was only 8.5 in a range of 0 to 100. Another possible explanation has been given by Hume et al. (28). Their study showed that normal activities of daily life only 39% of the possible range of motion of the finger was required. Hardly any patient was this far limited in his movements, implying that he would not have many difficulties in normal life. Another shortcoming in measuring the range of motion is that it has never been tested for reliability. Only goniometric assessment of a single joint ROM in one finger has proved to be reliable (29), but summating two or three joints is likely to be less reliable. Further research in this respect is necessary.

Evaluating strength in hand and finger also gives rise to some problems. Individual differences are important, and depend on sex, age and work. Normative tables have been drawn up for grip strength (30, 31), but have very high standard deviations, making it quite unrealistic to predict normal strength for one individual. The 10%-rule, in which strength in the dominant hand is considered to be 10% more than strength in the non-dominant hand, has been extensively studied and seems to be true for right-hand dominant, but not for left-hand dominant individuals (22). However, there is no consensus, so some authors use this rule and some do not, again making comparison difficult. We reported both numbers, but suggest using the rule for right-hand dominant individuals only. The 10%-rule does not seem to hold for pinch strength (24, 32). Though small, there was a clearly better correlation between pinch strength and DASH-score than between grip strength and DASH-score. Since strength is significantly affected in our study, just as in others’s, and since this has a repercussion on function, the evaluation of strength should be part of the results of flexor tendon repair. It seems most sensible to use pinch strength. It represents a more specific measurement of the injured finger. Silfverskiold et al. (33) showed that grip strength in zone 2 injuries was significantly influenced by the ROM of the finger, the number of injured fingers and whether the injured finger was the little or middle finger. This makes grip strength a difficult measure for the interpretation of flexor tendon repair.

Functional questionnaires have proved to be very useful tools in evaluating the results of many diseases. The major aim of any treatment should be to minimize problems that patients experience in everyday life. A specific questionnaire has not yet been used for flexor tendon repair. The DASH-questionnaire did not prove useful in our study, since its sensitivity was inadequate. One reason may be that the pathology is not serious enough to show large score differences. However when compared to results in other diseases, the difference is enormous (Table V) and can hardly be explained by this argument only. Another reason may be that the DASH-inquiry was made orally. This could possibly bias the answers patients gave. However, it also revealed an indistinctness in the questions posed. Indeed the DASH asks quantification of the difficulties in performing tasks, regardless of which hand is used. In their original presentation of the test Hudak et al. (10) stated that this is important in
assessing the entire functioning of the patient. Whether the patient changes over from his right hand to his left when turning keys is not important. It is important to know if he still has difficulties in turning keys. While posing the questions most patients didn’t understand this, so some extra explanation was given. This was only possible because the test was taken orally. Obviously this could lead to much lower scores. Further research in this area is needed.

In conclusion, the ROM obtained after flexor tendon repair may provide information about the surgical technique. However, classifying results as excellent, good, fair and poor is irrelevant. Results should be reported as a percentage of the contralateral finger. Standard deviation gives an idea of the spread of these results. Calculating the percentage of the contralateral, healthy finger can only make results more accurate than reporting ROM of the injured finger in degrees, since normal ROM is not the same in every subject or every finger. The only disadvantage of this method is that subjects that do not have a healthy opposite finger would have to be excluded. However, in studying results for scientific purpose, especially when functional tests are used, these subjects could not be included anyway, since it will be impossible to differentiate which injury causes the disability. It is recommended that the MCP-joint is included, since the ROM of this joint can be affected in zones other than zone 2 (1, 27). The problem remains that the range of motion is not the only important factor in the result. Since so many factors are interfering it would be interesting to evaluate the result using a functional questionnaire that provides good information about the impairments of the patient. The DASH-questionnaire did not prove useful in our study. Further study is required to establish a questionnaire that can be used in flexor tendon repair.

References


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