


Patient-reported outcome measures and their association to the original Strickland classification after flexor tendon repair

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Abstract

The aim of this study was to examine the relationship between patient-reported outcome measures (PROMs) and the original Strickland classification after flexor tendon injuries in Zones 1 and 2. Data were collected from the Swedish national health care registry for hand surgery (HAKIR). The studied PROMs were the Quick Disabilities of Arm, Shoulder and Hand (QuickDASH) and the patient questionnaire from the HAKIR (HQ-8). Complete data of both range of motion (ROM) and PROMs were available for 215 patients at 3 months after surgery, and for 150 patients at 12 months after surgery. We found that QuickDASH values were low and similar between all groups as classified by the Strickland system at 12 months. A statistically significant difference between PROM values (for stiffness and satisfaction) was found only between the Strickland groups Fair and Good, but not between Poor and Fair or Good and Excellent. This suggests that further categorization according to the Strickland classification is less important to the patients as long as they regain 70% of their ROM.

Level of evidence: III

Keywords

Hand, finger, DASH, range of motion, patient-reported outcome measure

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Introduction

The extent to which a patient recovers after a flexor tendon injury is dependent on a number of factors, such as injury-related characteristics (e.g. mechanism, location), surgical technique (e.g. adequate coaptation, strength of the repair), patient factors (e.g. comorbidities, motivation) and postoperative care (Johnson et al., 2020). New techniques, including multiple strand repair and early active mobilization, are thought to lead to better functional results and their results should therefore be properly assessed. There are a number of different assessment systems that are or have been used, making comparisons between the results obtained very difficult. Most studies measure the range of motion (ROM) in degrees of the injured finger (Libberecht et al., 2006), which is then converted to one of

typically four words of quality (Excellent, Good, Fair and Poor) using a predetermined set of criteria (Karjalainen et al., 2019). The criteria most used are those of Strickland's original method (Strickland and Glogovac, 1980); however other methods, such as that

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of Buck-Gramcko or the total active motion as proposed by the American Society for Surgery of the Hand (ASSH) are also used occasionally (Shaw et al., 2022; Tang, 2005). The classification into four groups (Excellent, Good, Fair and Poor) is an interpretation that has not been thoroughly validated in terms of how it relates to patient-reported outcome measures (PROMs) (Karjalainen et al., 2019). PROMs provide a means of quantifying the severity of symptoms and the magnitude of limitations from the patient's perspective. Previous research has shown that PROMs are more strongly associated with return-to-work after a distal radial fracture compared with traditional objective measures (MacDermid et al., 2007). There are no validated specific PROMs after flexor tendon repair (Woythal et al., 2020). Disabilities of Arm, Shoulder and Hand (DASH) and the shorter version, QuickDASH, are frequently used PROMs in other fields of hand surgery (Farzad et al., 2015).

Our aim was to examine the relationship between the Strickland classification and patient-reported outcomes (QuickDASH and HQ-8) as well as satisfaction with outcome in patients who had undergone flexor tendon repair in Zone 1 and 2.

Methods

We assessed data collected in the Swedish national health care registry for hand surgery (HAKIR). All patients with a complete flexor tendon injury in Zones 1 and 2 who had a flexor tendon repair between 2010 and 2020 were included at the time of flexor tendon repair. Patients with concomitant fractures, extensor tendon injuries or microvascular surgery are not included in HAKIR. Exclusion criteria were reoperation within the first year after primary repair and patients below 16 years of age. The HAKIR design has previously been described (Arner, 2016) and includes data on the repair, 3 and 12 months follow-up with clinical assessment and patient questionnaires. Data from clinical assessments included the range of motion in the proximal interphalangeal (PIP) and distal interphalangeal (DIP) joints of the injured finger when making a closed fist. These were measured by an experienced physio- or occupational therapist with a goniometer following a standardized measurement manual. Information on whether a cut flexor digitorum superficialis (FDS) tendon was sutured or not is not included in the HAKIR registry. The questionnaire consists of the HQ-8 questions that include patients' perception of problems on an 11-point Likert scale ranging from 0 (no problems) to 100 (worst problems imaginable), with a 10-point difference between each step. The HQ-8 has previously been assessed for construct

validity, floor and ceiling effect and magnitude of change (Carlsson et al., 2021). The questionnaire also includes a question on perceived satisfaction with results on an 11-point Likert scale ranging from 100 (completely satisfied) to 0 (not satisfied) in 10-point steps and the Swedish version of the QuickDASH (Gummesson et al., 2006). The questionnaires are issued as web questionnaires or filled out on paper, at 3 and 12 months after repair.

The sum of active motion in the PIP and DIP joints was calculated as a percentage of normal (flexion minus extension deficit divided by 175°). We classified the active motion according to the original Strickland classification (Poor: <50%, Fair: 50–69%, Good: 70–84%; and Excellent: >85%) (Strickland and Glogovac, 1980).

Most patients were treated with a 4-strand core suture technique. A looped suture (Tsuge technique) with a braided polyester suture was used in over half of the cases. The rest were treated with a modified Kessler suture, by re-insertion to the distal phalanx or by another method that was most often not specified. Eighty per cent of patients were rehabilitated using a controlled early motion regimen. Other forms of rehabilitation were modifications of the Kleinert regimen and active hold exercises.

Statistical analysis

Normally distributed data are presented as the mean and standard deviation (SD). Data that were not normally distributed are presented as the median and interquartile range (IQR).

All statistical calculations were done to compare patient outcomes rather than digit-specific outcomes. To compare the range of motion in patients with multiple finger injuries, the finger with the worst ROM was used.

Ordinal and multinomial logistic regression was used to examine the association between patient-reported outcomes and the original Strickland grade at 3- and 12-months follow-up. Single variables and their association with the Strickland grade were assessed with ordinal regression. This was expressed as the odds ratios (OR) with 95% confidence intervals (CI) of being in a higher category of Strickland grade as a 10-unit change in the variable. To test the assumption of proportional odds we used the test of parallel lines. We interpreted a p -value of <0.05 as a rejection of the hypothesis of proportional odds. For all other statistical analyses, $p < 0.05$ was considered significant. To assess the potential influence of confounders we carried out multiple ordinal regression, including the potential confounders (injury to dominant hand, multiple injured finger (yes or no)

and concomitant nerve injuries (yes or no)) to the models with PROM variables. A confounding effect was defined as a change in OR of >10% compared with the model without potential confounders.

Results

We identified two groups of patients with complete data sets, including questionnaires and ROM at different time points. In total, 215 patients were analysed at 3 months and 150 patients at 12 months after flexor tendon repair. Eighty-nine of the patients available for analysis at the 12-month follow-up were also part of the cohort analysed at 3 months. The remaining 61 patients in the 12-month follow-up had either completed only the PROMs or the ROM at 3 months, or there were no data at 3 months. Injury and patient characteristics are shown in Table 1. The clinical results at 3 and 12 months are shown in Table 2.

The associations between PROM values and level of Strickland at the 3 and 12 months are shown in Table 3. There was a significant association at 3 months between the level of Strickland grade and the QuickDASH score as well as HQ-8 items on stiffness and ability to perform daily activities. When the PROM value increased (i.e. got worse), the OR of being in a better Strickland category decreased. At 12 months there was a significant association

between the level of Strickland and QuickDASH as well as HQ-8 item on stiffness. The patients' satisfaction with the result was also significantly associated with their Strickland level at 3 and 12 months. Adjusting the results for the possible confounders (injury to the dominant hand, multiple injured fingers and concomitant nerve injury) did not alter the OR by >10% and were thus not considered of importance for the interpretation of the results.

Owing to the violation of the assumption of proportional odds, we assessed the significant variables with a multinomial logistic regression (Table 4). There was an association between perceived stiffness and Strickland levels Good and Fair. An increase in perceived stiffness decreased the OR of being in the Good category compared with the Fair category. There was an association between QuickDASH and Strickland levels Fair and Poor at 3 months. An increase in QuickDASH decreased the OR of being in the Fair category compared with the Poor category. There was also a statistically significant difference in satisfaction with the result between Strickland levels Good and Fair at 12 months. A higher satisfaction increased the OR of being in the Good category compared with the Fair category. There was no association between perceived stiffness, QuickDASH, satisfaction and being in any other ascending Strickland category at 3- or 12-months follow-up. Figures 1 and 2 depict the Strickland classification and the PROMs that were found to have a statistically significant difference (QuickDASH, stiffness and satisfaction with the result) between the different Strickland groups.

Table 1. Patient and injury characteristics at 3 and 12 months after flexor tendon repair in Zones 1 and 2.

Patient and injury characteristics	3 months	12 months
Age in years (mean [SD])	39 (15)	38 (15)
Sex (%)		
Women	74 (34)	56 (37)
Men	141 (66)	94 (63)
Operated hand (%)		
Right	93 (43)	62 (41)
Left	122 (57)	88 (59)
Injury to dominant hand (%)		
Yes	98 (46)	66 (44)
No	117 (54)	84 (56)
Type of tendon injury (%)		
FDP	124 (51)	89 (51)
FDP + FDS	120 (49)	84 (49)
Number of fingers injured (%)		
Single	190 (88)	133 (89)
Multiple	25 (12)	17 (11)
Injury to digital nerve (%)		
No	153 (63)	98 (57)
Yes	91 (37)	75 (43)

FDP: flexor digitorum profundus; FDS: flexor digitorum superficialis.

Discussion

Flexor tendon injuries are common, and yet there is no consensus on how best to assess the results of their treatment. The current study identifies four PROMs (QuickDASH, stiffness, ability to perform daily activities and satisfaction with the result) that have an association with the Strickland classification. In this study, most of these PROM values were only associated between Strickland levels Fair and Good, but not between Poor and Fair, or Good and Excellent. The QuickDASH values were low and similar between all Strickland groups at 12 months. The minimally clinical important (MCID) difference for QuickDASH after flexor tendon injuries has not been described (Franchignoni et al., 2014), but it has been described to be 6.8 in a population with various hand surgical conditions (Kazmers et al., 2020). In our study QuickDASH was associated only between the Poor and Fair Strickland level at 3 months. The difference in median QuickDASH values between these categories was 16, indicating

Table 2. Patient-reported outcome at different levels of Original Strickland at 3 and 12 months after flexor tendon repair in Zones 1 and 2.

Strickland level	Poor		Fair		Good		Excellent	
	n	(%)	n	(%)	n	(%)	n	(%)
Month	3		12		12		12	
n (%)	55	(26)	26	(17)	31	(21)	40	(19)
QuickDASH	30	(16 to 40)	14	(5 to 34)	11	(9 to 23)	9	(2 to 21)
Pain on loading (HQ-8)	30	(10 to 35)	20	(2.5 to 47.5)	10	(0 to 30)	10	(0 to 40)
Pain on motion without load (HQ-8)	10	(0 to 20)	0	(0 to 17.5)	0	(0 to 15)	5	(0 to 20)
Pain at rest (HQ-8)	0	(0 to 10)	0	(0 to 17.5)	0	(0 to 10)	0	(0 to 10)
Stiffness (HQ-8)	50	(30 to 70)	50	(30 to 70)	40	(30 to 70)	40	(20 to 50)
Weakness (HQ-8)	40	(25 to 60)	30	(20 to 50)	30	(15 to 50)	40	(20 to 60)
Numbness/tingling in fingers (HQ-8)	20	(0 to 35)	10	(0 to 40)	10	(0 to 25)	10	(0 to 40)
Cold Sensitivity (discomfort on exposure to cold) (HQ-8)	30	(10 to 70)	60	(12.5 to 77.5)	40	(0 to 70)	20	(0 to 55)
Ability to perform daily activities (HQ-8)	30	(10 to 45)	15	(2.5 to 37.5)	10	(10 to 30)	10	(0 to 30)
Satisfaction with the result ^a	70	(50 to 90)	70	(50 to 80)	80	(60 to 100)	90	(70 to 100)
							85	(67.5 to 100)
							95	(80 to 100)
							90	(70 to 100)

HQ-8: The eight-item HAKIR questionnaire.

Values in table represent the median with the interquartile range in parenthesis.

^a11-point Likert scale ranging from 0 to 100 in 10-point steps (0 = no problems, 100 = worst problems imaginable).

^a11-point Likert scale ranging from 0 to 100 in 10-point steps (0 = completely dissatisfied, 100 = completely satisfied).

Table 3. Crude association between patient-reported outcome variables and odds ratio for higher level of original Strickland grade, 3 and 12 months after flexor tendon repair.

Variable	3 months OR (95% CI)	12 months OR (95% CI)
QuickDASH	0.72** (0.58 to 0.88)	0.80* (0.64 to 0.98)
Pain on loading (HQ-8)	0.97 (0.86 to 1.08)	1.01 (0.90 to 1.14)
Pain on motion without load (HQ-8)	0.96 (0.83 to 1.10)	1.05 (0.89 to 1.22)
Pain at rest (HQ-8)	1.06 (0.89 to 1.22)	0.98 (0.79 to 1.18)
Stiffness (HQ-8)	0.77** (0.67 to 0.87)	0.75** (0.64 to 0.87)
Weakness (HQ-8)	0.98 (0.88 to 1.08)	0.92 (0.81 to 1.05)
Numbness/tingling in fingers (HQ-8)	0.97 (0.89 to 1.07)	0.99 (0.88 to 1.10)
Cold sensitivity (discomfort on exposure to cold) (HQ-8)	0.94 (0.87 to 1.03)	0.94 (0.86 to 1.03)
Ability to perform daily activities (HQ-8)	0.81* (0.71 to 0.93)	0.96 (0.84 to 1.08)
Satisfaction with the result ^a	1.16** (1.07 to 1.26)	1.21** (1.09 to 1.33)

OR: odds ratio for being in a higher level of original Strickland as 10-unit of change in variable; HQ-8: the eight-item HAKIR questionnaire. 11-point Likert scale ranging from 0 to 100 in 10-point steps (0 = no problems, 100 = worst problems imaginable).

^a11-point Likert scale ranging from 0 to 100 in 10-point steps (0 = completely dissatisfied, 100 = completely satisfied).

Statistically significant results shown in bold font (* $p < 0.05$, ** $p < 0.001$).

Table 4. Associations between level of Strickland original classification and patient reported outcome at 3 and 12 months follow-up. Odds ratios for being in the next ascending category compared with the reference category.

Follow-up	Level of Strickland	Reference	Stiffness ^a OR (95% CI)	Quick-DASH OR (95% CI)	Satisfaction ^b OR (95% CI)
3 months	Fair	Poor	0.95 (0.80 to 1.10)	0.69* (0.48 to 0.92)	1.10 (0.97 to 1.23)
	Good	Fair	0.82* (0.67 to 0.97)	0.90 (0.66 to 1.15)	1.08 (0.94 to 1.22)
	Excellent	Good	0.88 (0.69 to 1.06)	1.03 (0.75 to 1.32)	1.07 (0.89 to 1.25)
12 months	Fair	Poor	0.98 (0.78 to 1.19)	0.94 (0.68 to 1.21)	0.95 (0.77 to 1.13)
	Good	Fair	0.68* (0.47 to 0.89)	0.88 (0.61 to 1.16)	1.27* (1.07 to 1.47)
	Excellent	Good	1.00 (0.81 to 1.19)	0.91 (0.64 to 1.18)	1.06 (0.87 to 1.26)

^aHQ-8: the eight-item HAKIR questionnaire. 11-point Likert scale ranging from 0 to 100 in 10-point steps (0 = no problems, 100 = worst problems imaginable).

^b11-point Likert scale ranging from 0 to 100 in 10-point steps (0 = completely dissatisfied, 100 = completely satisfied).

Statistically significant values shown in bold font (* $p < 0.05$).

a clinically relevant difference early in the rehabilitation process. This difference was however not present at the 12-month follow-up. Another study by Libberecht et al. (2006) also found only a limited correlation between the DASH score and total active motion (TAM). Although DASH has shown validity, reliability and responsiveness in hand and wrist disorders (Dacombe et al., 2016), there is limited knowledge about its psychometric properties in patients with injured fingers. A weak correlation between DASH and impairment after phalangeal fractures has also been shown (van Oosterom et al., 2007). We regard both the DASH questionnaire, and its shorter version, the QuickDASH, as quite general and broad, and further investigation is needed to prove their potential value in the assessment of finger injuries.

To better understand the patient perspective, more targeted PROMs are needed. In this study,

the HQ-8 questionnaire was used. We found that patient-reported stiffness, ability to carry out daily activities, as assessed by a single question, and the patients' satisfaction with the result were associated with the Strickland classification. We identified two distinct clusters of patients with regard to both stiffness and satisfaction. The cut-off point between these groups seems to be the distinction between Fair and Good according to Strickland, corresponding to 70% of normal digital motion, or 120° of combined motion at the PIP and DIP joints. Patients classified either as Excellent or Good had similar self-reported stiffness and satisfaction with the results, as did the patients who were classified as either Fair or Poor. Therefore, it seems that what is most important to the patient is regaining 70% or more of their range of motion. A distinction between Good and Excellent or Poor and Fair seems less relevant to their subjective experience. Another flaw in the Strickland

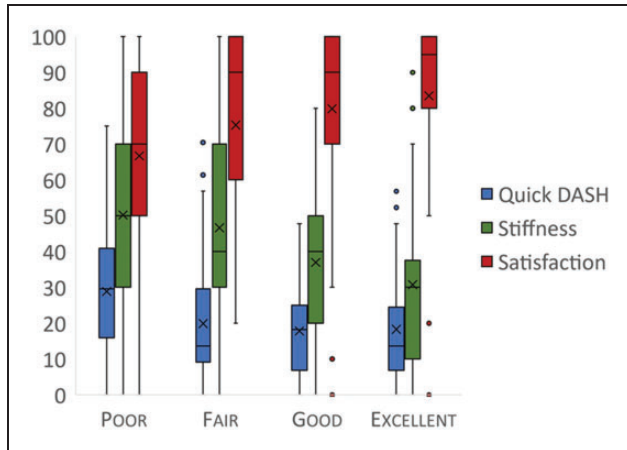


Figure 1. Patient-reported outcome measures and Strickland level at 3 months after flexor tendon repair. For stiffness, 0 corresponds to no problems and 100 to the worst problems imaginable, in 10-point steps. For satisfaction 0 corresponds to completely dissatisfied and 100 to completely satisfied, again with 10-point steps. Boxes are defined by the 25th and 75th percentiles, with x representing the mean value and the horizontal line representing the median value. Whiskers show the minimum and maximum values. Data are shown as outliers (dots) if their value is 1.5 times larger than the 75th percentile or 1.5 times smaller than the 25th percentile.

classification is that it does not consider which finger is injured or at which joint the movement occurs. It also does not directly account for extension deficits, only the total range of active motion.

Our results are supported in a study by Karjalainen et al. (2019). In their study of 49 patients with 57 injured rays (Zones 1–5) they found that the best cut-off value in TAM between Good and Excellent, as reported by the patients, was 75% of the uninjured side. They also found that both TAM and movement at the DIP joint correlated with perceived disability. The correlation was lost however, when translated to words of quality according to the classification systems they used (American Society for Surgery of the Hand, Strickland–Glocovac or revised Strickland). The same conclusion was reached by Libberecht et al. (2006).

The main strength of this study is the large amount of available data and the uniform assessment points of patients after repair. To our knowledge, no previous study has included so many patients with injury in Zones 1 and 2. The previous studies by Karjalainen et al. (2019) and Libberecht et al. (2006) included Zones 1–5 and the latter also included patients with an FDS injury only.

This study explores the relationship between Quick DASH, the items on the HQ-8 questionnaire and a question on patient satisfaction with the

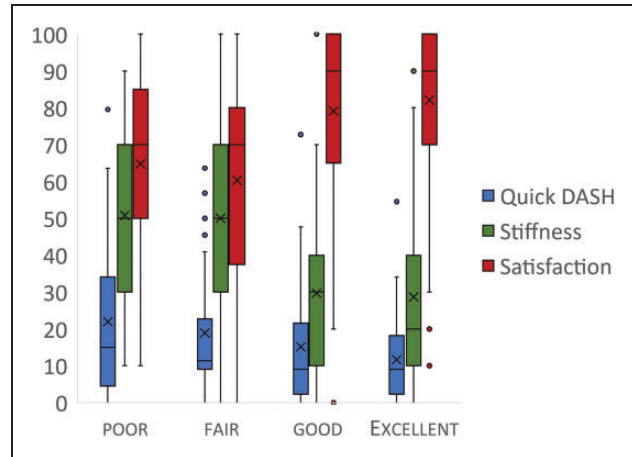


Figure 2. Patient-reported outcome measures and Strickland level at 12 months after flexor tendon repair. For stiffness, 0 corresponds to no problems and 100 to the worst problems imaginable, in 10-point steps. For satisfaction 0 corresponds to completely dissatisfied and 100 to completely satisfied, again in 10-point steps. Boxes are defined by the 25th and 75th percentiles, with x representing the mean value and the horizontal line representing the median value. Whiskers show the minimum and maximum values. Data are shown as outliers (dots) if their value is 1.5 times larger than the 75th percentile or 1.5 times smaller than the 25th percentile.

Strickland classification at two separate time points after surgery. Eighty-nine of the patients included in the analysis at 12 months were also present in the cohort analysed at 3 months. This could introduce a risk of bias. However, the aim of this study was not to examine how a possible correlation between the PROMs and the Strickland classification varies over time, nor have we done such an analysis. We can simply state that in our study, we have similar results at 3 and 12 months after surgery.

One limitation of this study is that patients below the age of 16 and patients requiring reoperation within 12 months of the initial surgery were excluded. A more thorough subgroup analysis may reveal other factors of importance for perceived stiffness and satisfaction. Future studies should investigate potential age or gender differences and whether patients rate disability differently based on what finger or hand is affected.

Based on our findings we propose that the most important clinical measurement after flexor tendon repair is whether the patient has regained at least 70% of normal digital motion. By 12 months after operation, differences in PROMs for stiffness and patient satisfaction could be found between the Strickland groups Fair and Good but not between Poor and Fair or Good and Excellent. This suggests that, from the patient's perspective, the four Strickland classification groups can be pooled

together into two groups: Poor/Fair and Good/Excellent. Also, we found that there was a high correlation with a single item PROM on problems with daily life activities and QuickDASH, suggesting that the full questionnaire might be unnecessary.

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