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Critical Angles of Deformity in Dupuytren's Contracture of the Little and Ring Fingers

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Background: We aimed to determine the degree of contracture in the ring and little fingers at which hand function became importantly impaired.

Methods: Five activities of daily living were incorporated into a newly developed and validated Dupuytren's assessment tool (DAT). Sixty healthy participants were assessed with the DAT wearing a range of 12 dorsal blocking splints. Half wore them on their right little finger, the other half on their ring finger. These induced flexion deformities mimicking DC of the MCPJ, PIPJ and a combination of the two. The angles of flexion deformity at which important hand disability occurred were calculated using receiver operating characteristic curves.

Results: Clinically important hand disability occurred for the little finger MCPJ, PIPJ and combined MCPJ and PIPJ angulation at 52.5, 67.5, and 75 degrees respectively. For the ring finger joint, the angulations were 52.5, 67.5 and 75 degrees respectively.

Conclusions: This information will provide information for clinicians and patients as to when clinically important disability tends to occur in DC.

Keywords: *Angle, Deformity, Disability, Dupuytren's contracture, Function*

INTRODUCTION

Dupuytren's contracture (DC) causes a progressive flexion deformity commonly affecting the ulnar two digits of the hand. Currently surgery is the gold standard treatment that can correct deformity and improve hand function.[1,2] Indications for surgery are based upon the patient's disability as well as surgeon preference. In the UK, guideline indications created by the British Society for Surgery of the Hand (BSSH) include, flexion contractures of the metacarpophalangeal joint (MCPJ) greater than 30 degrees, of the proximal inter-phalangeal joint (PIPJ) of any degree or a positive Hueston table top test.[3] However there is scarce evidence to support these and moreover they are not finger specific. Quantification of the degree of severity of DC with hand disability would greatly aid surgical decision-making and better manage patient expectations.

Multiple outcome measures have been used to assess DC and have been able to detect postoperative changes in hand function.[1,2,4-7] However they have not been able to correlate the degree of contractures with disability as they are not disease specific; are time consuming in the clinical setting and importantly they have not had a clinically important difference (CID) in change score ascribed to them for measuring patients with DC.[8,9]

The CID for a patient reported outcome measure (PROM) determines, from the point of view of the patient, whether an important change has occurred in their condition.[10] It is commonly calculated by associating clinical meaning to a change score, achieved via a patient rated external criterion such as the Patient Global Impression of Change (PGIC) scale.[9-11] Calculation of

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the CID gives a generic PROM, such as the Numerical Rating Scale (NRS), a meaningful change score that correlates with a clinically perceived change for a specific disease. Through these techniques, our aim was first to design and validate a DC specific questionnaire and then with it quantify the degree of angulation of DC most associated with its CID score.

Objectives

Phase 1: To create and validate a Dupuytren's assessment tool (DAT) for DC based upon an 11 point numerical rating scale and determine its clinically important difference (CID).

Phase 2: To determine the flexion angles associated with the CID for:

a. the little finger MCPJ, PIPJ and a combination of both,
b. the ring finger MCPJ, PIPJ and a combination of both.

METHODS

Materials

Ethical approval was obtained from the university ethics research & development department.

Table 1. Dorsal Hand Splint – Degrees of Flexion Deformity

	*MCPJ	*PIPJ	Cumulative PIPJ and MCPJ*
Right little finger	30	30	30
	45	45	60
	60	60	90
	75	75	120
Right ring finger	30	30	300
	45	45	60
	60	60	90
	75	75	120

*Total angulation divided between both joints, i.e 30° is a combined total of 15° at the PIPJ and 15° at the MCPJ.
*MCPJ: Metacarpophalangeal joint, *PIPJ: Proximal interphalangeal joint.

Twenty-four generic thermoplastic dorsal blocking splints were made (Table 1). The ranges of angles were chosen to include those in the BSSH guidelines and in previous studies investigating hand function and DC deformity.[1-7] They were fastened with elastic Velcro strapping around the palm and proximal phalanx to the right hand of the participants to allow for flexion of the digit. Adhesive felt padding was applied to its inner surface to allow improved fit among participants. Participants were asked if the splint fitted closely to their finger. These splints induced an array of flexion deformities to mimic a range of contractures found in DC.

Methods

Inclusion criteria

1. Healthy participants without any pre-existing hand conditions.
2. Ability to understand and consent to the trial.

Exclusion criteria

1. Participants with hand deformity/dysfunction.
2. Participants with learning disabilities.
3. Participants whose hands did not fit the pre-modeled dorsal hand splints.
4. Individuals refusing to participate/consent.

The study methodology included 2 phases. Phase 1 entailed the development of the Dupuytren's assessment tool (DAT) and its clinically important difference (CID) score. Phase 2 utilizes the DAT and its CID to find out the critical joint deformity angles at which hand function is impaired.

Phase 1

Phase 1 comprised:

1. The design of the DAT
2. The validation of the DAT
3. The calculation of the CID score for the DAT
4. The calculation of the sample size for phase 2 of the study.

Table 2. Activities of Daily Living

Task	Description
Typing	Subjects type 'I am absolutely delighted to be participating in this Dupuytren's contracture study.'
Face-washing	Subjects simulate face washing with the aid of a disposable flannel.
Putting on gloves	Subjects put on a rubber washing up glove (large enough to accommodate a dorsal splint) on the affected hand.
Coin retrieval from a trouser pocket	Subjects retrieve a 50 pence coin from their right trouser pocket (To assess individual's ability to place their hand into their pocket and withdraw it).
Retrieving a small book from a shelf space	Subjects retrieve a small book from between 2 larger books 2 cm apart (To assess an individual's ability to use their hand in a confined space).

Design of the Dupuytren's Assessment Tool (DAT)

The DAT is an 11-point numerical rating scale (NRS) that was developed to assess hand function in subjects with an extension deficit deformity similar to that found in DC. The score is the average rating of 5 activities of daily living (ADLs) deemed problematic for Dupuytren's sufferers (Table 2). ADL selection was based upon a literature review, discussion amongst consultant hand surgeons, feasibility - taking into account availability of resources, and included ADLs featured in the validated and Dupuytren's disease-specific 'Unité Rhumatologique des Affections de la Main' (URAM) scale.[12-14) This French-language 9-item scale correlates with the Tubiana score as well as a patient-reported Visual Analogue Scale for disability in patients pre- and post- needle aponeurotomy.[3] Although it was a candidate measure for use in our study, it was deemed too lengthy and inefficient, as items 1, 2, 7, and 9 were inappropriate for our study methodology. It was however used in phase 1 of this study to ensure convergence with our DAT and thus its construct validity.

Performance of each ADL was given a numerical rating with 10 being normal hand function and 0 being intolerable (Fig. 1). ADLs were performed with a dorsal blocking splint fastened to their individual MCPJ, PIPJ or both (little or ring) of the right hand. After each ADL, the participant was asked: "Can you rate, on a scale of 0 to 10, the ease with which you can use your hand. Ten is your normal everyday hand function, without the splint and 0 is intolerable." The mean of the 5 ADL scores gave a DAT score for that degree of deformity for that joint.

Validity

Validation of the DAT entailed testing for reproducibility, responsiveness to change, internal consistency of the 5 tasks, and construct validity.

Reproducibility was calculated by using Pearson's correlation coefficient statistic when the repeat test was carried out 1 week later. Responsiveness of the DAT to change in participant disability was determined by the effect size between PGICs of 5 & below and 6 & above. Cronbach's Alpha analysis investigated internal consistency of the items in the DAT. Pearson's correlation coefficient assessed convergence of the DAT scores with the URAM scale.

Calculation of the CID for the DAT scale

The CID score for the DAT scale was calculated by correlating its change scores, taken from a set of participants who had initial splint-induced deformity followed by a lesser or absent deformity, with levels of change in hand function as determined by the Patient Global Impression of Change (PGIC) described below.

20 participants were recruited; ten participants were assessed with ring finger splints and ten with little finger splints. The angulations of these splints were chosen at random from Table 1, therefore representing a range of deformities across both joints. Participants were assessed again either with a lesser angulated splint of the same finger or without one at all. These 2 assessments gave 'pre-treatment' and 'post-treatment' DAT scores in order to calculate the raw change scores. The effect size statistic was calculated by dividing each individual raw change score by the standard deviation of the group baseline scores. Effect size of 0.2 represents a small change, 0.6 moderate and 1 substantial.[15] Participants were also asked to rate their improvement in hand function between the 2 assessments using the Patient Global Impression of Change (PGIC) - a discrete 7-point scale with 1 representing "no change" and 7 representing "a great deal better" (Fig. 1).[16] The a priori definition of clinically important change suggests that PGIC values of 6 or more correlate best with actual change.[10,11,17]

Illustrations

No change	Almost the same	A little better	Somewhat better	Moderately better	Better	A great deal better
1	2	3	4	5	6	7

Explanation:
1 = No change (or condition has got worse)
2 = Almost the same, hardly any change at all
3 = A little better, but no noticeable change
4 = Somewhat better, but the change has not made any real difference
5 = Moderately better, and a slight but noticeable change
6 = Better, and a definite improvement that has made a real and worthwhile difference
7 = A great deal better, and a considerable improvement that has made all the difference

Fig. 1. Patient Global Impression of Change (PGIC) scale.

Sensitivity, specificity and accuracy of each level of effect size (0.2, 0.6 and 1) against perceived change as per PGIC (6 and above versus 5 and below) were calculated. Cut off value of effect size that gave the best balance between sensitivity and specificity (highest accuracy) was chosen. The corresponding raw change score was defined as the most fitting in identifying CID.[18)]

Sample Size Calculation for Phase 2

The effect size, an alpha value of 0.05 and 80% power allowed extrapolation of a sample size for phase 2 using a standard nomogram.

Phase 2

Phase 2 determined the joint angle deformities of the ring and little finger MCPJ, PIPJ and of both joints at which the CID for the DAT scale was reached.

New participants were allocated for phase 2. Each participant was evaluated by the DAT with each of the 12 dorsal splints in Table 1 fastened to their right hand. Therefore each participant performed the set of 5 ADLs 12 times. As during unrestricted full hand function, the DAT score would be 10, the DAT score for each joint angle was subtracted from 10 to obtain raw change scores.

ROC analysis was used to find the 'cut-off' joint angles with its associated set of DAT change-score. For each of the 12 angles of each finger, sensitivity was plotted against 1 - specificity, to obtain a ROC curve. The CID functioned as the gold standard and distinguished participants who are 'critically impaired' – the true positives, from persons who are 'not critically impaired' – the true negatives. Each angle's sensitivity is the number of participants who are 'critically impaired' according to the anchor. Its specificity is the number of persons in relation to the anchor, who are 'not critically impaired'.

The ROC derived 'cut-off' joint angle equates to the point of the curve closest to the upper left hand corner of the ROC graph. An area under the curve (AUC) more than 0.75 is considered to provide clinically useful discriminating ability of the 'cut-off' value.[19)]

RESULTS

Phase 1

20 recruits participated in this phase. Mean age was 29 (range 25–36) and nineteen were male. All were right–handed.

The intra-class correlation coefficient for test-retest reliability was r = 0.878 ($p < 0.001$) and the Pearson correlation for deformity severity against DAT score was r = 0.767. Cronbach's Alpha (internal consistency) for all the items in the questionnaire was 0.878. Every item was significantly contributing to the overall score, with each of the Cronbach's Alpha scores in the range of 0.833-0.872 if an item was deleted. Convergence with the URAM scale gave a co-efficient of r = 0.842.

The clinically important DAT change score (CID) was 3.025 for a PGIC of 6 and more compared to the to the group with PGIC of 5 and less which had a NRS change score of –0.667 ($p = 0.00065$).

Based on phase 1 data, we used CID for sample size calculation. For an alpha value of 0.05 and a power of 80% a sample size of 26 studying each finger was required for phase 2.

Phase 2

Little Finger Joint Critical Flexion Angles

Thirty participants were enrolled to assess little finger flexion contractures in phase 2. 23 were male and 28 were right handed. The age range was 17–35 and the

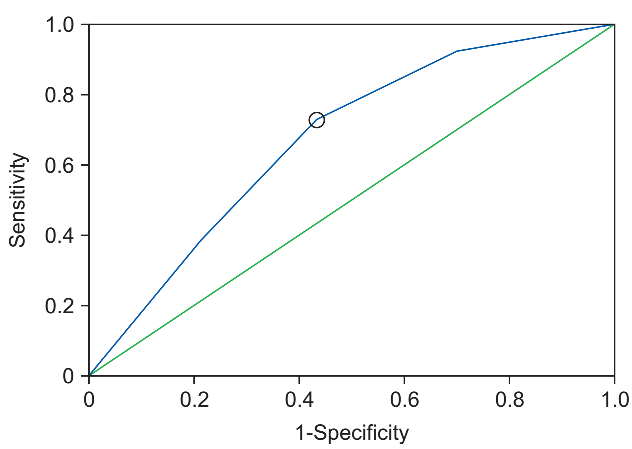

Fig. 2. Little finger MCPJ critical flexion angle ROC curve.

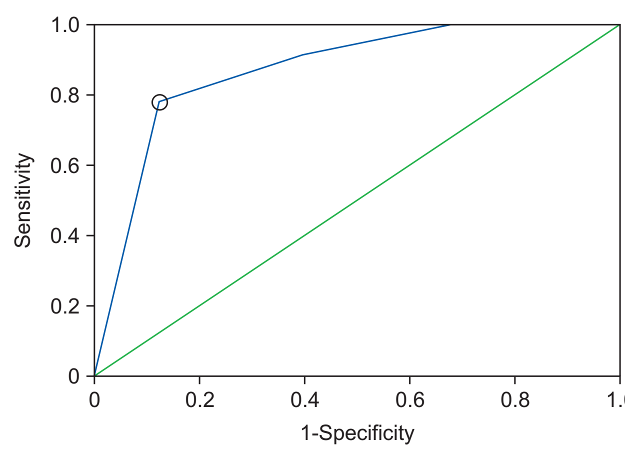

Fig. 3. Little finger PIPJ critical flexion angle ROC curve.

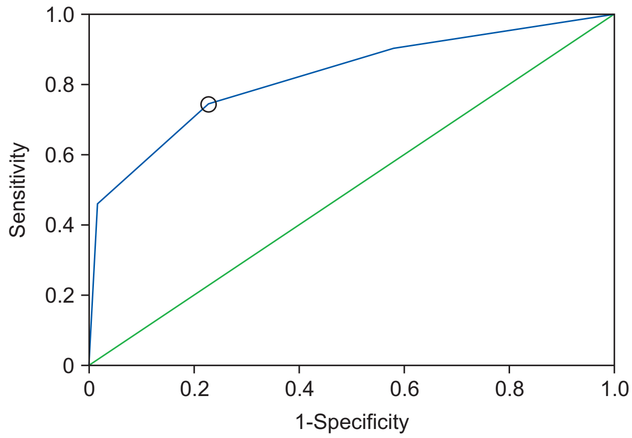

Fig. 4. Little finger MCPJ & PIPJ critical flexion angle ROC curve.

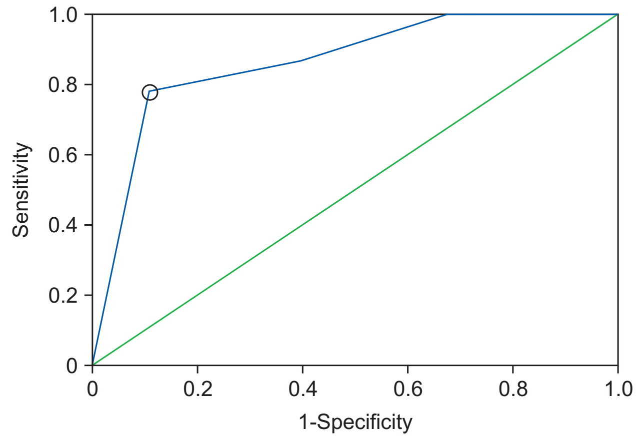

Fig. 6. Ring finger PIPJ critical flexion angle ROC curve.

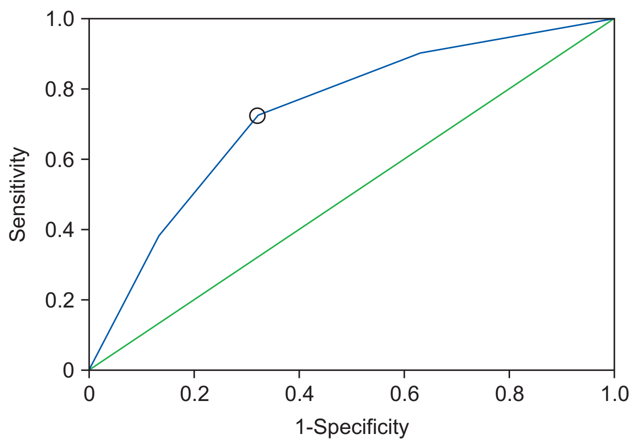

Fig. 5. Ring finger MCPJ critical flexion angle ROC curve.

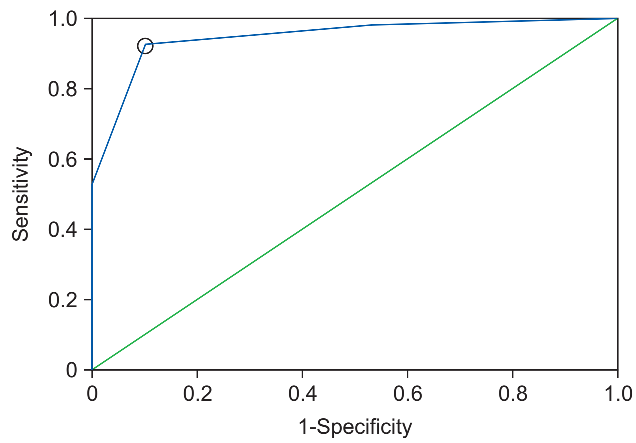

Fig. 7. Ring finger MCPJ & PIPJ critical flexion angle ROC curve.

mean age was 26.

The MCPJ angle at which hand function clinically deteriorated, as determined by ROC analysis, is 52.5° (AUC 0.672). The PIPJ angle is 67.5° (AUC 0.87). The combined MCPJ & PIPJ angle is 75° (AUC 0.822). The ROC curves for the little finger MCPJ, PIPJ and both joints are shown in Fig. 2, 3, 4 respectively.

Ring Finger Joint Critical Flexion Angles

Twenty-nine participants were enrolled to assess ring finger flexion angles in phase 2. Twenty-eight were male and 22 were right handed. The age range was 18-36 and the mean age was 29. The critical MCPJ angle for the ring finger is 52.5° (AUC 0.732). The PIPJ angle is 67.5° (AUC 0.865). The combined MCPJ & PIPJ angle is 75° (AUC 0.947). The ROC curves for the ring finger MCPJ, PIPJ and both joints are shown in Fig. 5, 6, 7 respectively.

DISCUSSION

Hand impairment in relation to flexion contractures has not been quantified before and as such indications for surgery have been based on conventional teaching, which proposes that a positive Hueston tabletop test should guide decision-making towards surgery. Our study has shown that the little and ring finger PIPJ flexion deformities both importantly affect hand function at an angle of 67.5 degrees. This new information suggests that greater flexion deformity of the PIPJ can be tolerated than previously thought and that the functional benefits of surgery may not be fully appreciated by the patient if operated on at a less severe stage. Larger combined angles of up to 75 degrees can be tolerated if the flexion contracture is equally spread across both the MCPJ and PIPJ for the little and ring fingers. The cut-off values MCPJ contractures of the ring and little fingers were 52.5 degrees. However with an associated AUC of 0.73 and 0.67 respectively, the discriminating ability for this angle is fair to poor. This suggests that hand disability induced by MCPJ contractures affects patients inconsistently and that the cut-off angle is likely to be variable from individual to individual. Of course, if this new information is to be incorporated into discussion between physician and patient, it must be tempered against the perspective that greater deformity is potentially more difficult to treat surgically and is associated with greater recurrence rates.[2,20,21]

Previous studies, using a variety of hand and upper limb measures, have shown improvements in scores for hand function after treatment of DC. However these studies have reported results in terms of statistical significance, which determine the likelihood that the observed effect occurred by chance, not whether these improvements are clinically meaningful.[22] Zyluk and Jaglieski used the DASH score to detect changes in upper limb function after subtotal fasciectomy for DC. They demonstrated a statistically significant improvement in the DASH score from 54 to 32 after subtotal fasciectomy, but were unable to correlate degree of preoperative flexion deformity with DASH score.[7] Jerosch-Herold et al. showed poor correlations (r = 0.2–0.3) between degree of flexion deformity of all four fingers and hand disability using the DASH questionnaire.[6] Budd et al. drew a similar conclusion investigating finger specific flexion deformity and the QuickDASH score. In their study they found a mean improvement of 7.14 in the score and an improvement of deformity by 68.1 degrees. Again, there was no correlation in change in QuickDASH score with change in range of movement in any of the fingers.[5] The only studies that found a correlation between deformity and hand function were those using the clinician-rated Sollerman Hand Function test, which requires the patient to undertake 20 tasks under observation and timed conditions using a range of prescribed handgrips. Sinha et al. reported a negative correlation between preoperative total flexion deformity and the Sollerman score and a positive correlation of the score with an improvement in deformity. This was associated with a six-point increase (an improvement in hand function) in the mean Sollerman score from 71 to 76 post surgery.[2] This was consistent with a study by Draviaraj et al, where 12 months after surgery, the absolute mean improvement in the score was 5.5 points out of 80. They found that improvements in Sollerman score correlated significantly with PIPJ correction (pre-operative mean – 35 degrees, mean correction – 16.2 degrees) but not MCPJ correction (preoperative mean – 31 degrees, mean correction – 22.1 degrees).[1] These findings support our results, which showed clinically important flexion deformity angulations of the PIPJ but not for the MCPJ.

Utilizing the concept of the CID in our DAT's scoring, we found that a change score of 3 was best associated with our a priori definition of clinically important improvement, namely the PGIC category of 'much improved' or better. Although, there are few studies that have utilized the numerical rating scale to assess function, many have used it to assess pain. These studies consistently found clinically important differences in scores on a NRS or VAS scale in the region of 2-4 points, which is similar to our change score.[10,17,23,24]

Our study had some limitations in its methodology and results. Our decision to involve healthy participants allowed us only to investigate the affect of acutely induced flexion deformity on hand disability. Any additional disability due to cords, nodules, concomitant finger involvement, the sensation of tightness when extending the affected finger and the effect of duration of disease could not be taken into account. The age range of the recruits was also lower than that of the population usually affected. The effect of age on hand function has not previously been investigated and therefore the applicability of our results to an older patient age group may not be appropriate. It is likely that a younger age group may be more forgiving of functional limitation, since other nearby joints are presumably normal. In patients who are older, there may be associated degree of dysfunction secondary to arthritis or additional Dupuytren's disease in adjacent fingers. Furthermore, the majority of our recruits were right handed, which does not reflect the distribution of handedness in the general population. In terms of the ADLs, we recognize that different types of glove may affect hand function, for example, size, material and elasticity. Similarly, the size and type of trouser pocket could also have affected the numerical rating score. Regarding our results, the small AUC for MCPJ ROC curves of both the little and ring fingers indicates that the critical flexion angle of 52.5 degrees is not an accurate discriminator of those with clinically important hand function impairment and those without. Our interpretation of this result is that functional impairment of hand may occur in the proximity of 52.5 degrees and that perhaps variable degrees of flexion deformity of this finger joint can be tolerated depending on the individual. Finally, the statistical technique employed, ROC analysis, dictates that the point for the most accurate cut off angle is one that is exactly half way between two consecutive splint angulations. This not only gives a very precise result but also obligates critical angulations, between different joints, to be exactly the same if functional deterioration occurred in the same interval between splints. Perhaps giving a range, for example "between 45-60 degrees" rather than the exact number "52.5 degrees" would be more clinically meaningful.

Given the nature of our methodology, the next step would be to repeat this study in patients with actual Dupuytren's contracture. In many physicians' views including that of the author, the impact of deformity on function can vary markedly from one patient with Dupuytren's to another depending on the individual's functional demands, tolerance and capacity to compensate for the disability over time. Having information from assessing actual patients with Dupuytren's contracture would not only be very useful but it would also be interesting to compare it with the results of this study.

In conclusion, this is a novel experimental study in young healthy individuals looking at an acutely introduced deformity. Although it does not completely mimic a true Dupuytren's contracture, it seems that individuals can tolerate relatively large flexion deformities before clinically important impairment in hand function occurs. It also demonstrates that little and ring finger PIPJ deformity causes functional loss of the hand more predictably than that of the MCPJ.

This study will be able to inform discussion between surgeon and patient regarding functional impairment associated with finger flexion deformities, and secondly, the methodology of this study would perhaps be a platform for future research incorporating patients with Dupuytren's.

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