Long-term follow-up of non-surgical treatment for thumb carpometacarpal osteoarthritis

A cohort study

Masterthesis

Physiotherapy Science

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"ONDERGETEKENDE

Lisa Maria Johanna Esteban Lopez,

bevestigt hierbij dat de onderhavige verhandeling mag worden geraadpleegd en vrij mag worden gefotokopieerd. Bij het citeren moet steeds de titel en de auteur van de verhandeling worden vermeld."

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ABSTRACT

Background: Treatment guidelines for thumb carpometacarpal (CMC-1) osteoarthritis (OA) advise starting non-surgical treatment. The combination of exercise therapy and the use of orthotics can result in a short-term decrease of pain and increase of function with a follow-up of one year. However, the existing evidence on the long-term effectiveness of non-surgical treatment, especially exercise therapy, is limited. Furthermore, the actual conversion to surgery has hardly been described.

Aim: To describe the outcomes of non-surgical treatment, consisting of exercise therapy and the use of orthotics, on patient reported pain and limitations in activities of daily life (ADL) in patients with CMC-1 OA after at least 5 year follow-up. Secondary outcomes include conversion to surgery within a follow-up period of at least 5 years and possible predictors at baseline, patient satisfaction and quality of life.

Methods: This is a multicenter, prospective cohort study with observational data investigating outcomes of an orthosis and exercise therapy using two samples. The primary outcomes were pain and limitations in ADL, expressed in the Michigan Hand Outcomes Questionnaire (MHQ) subscales pain and ADL respectively and were analyzed using linear mixed model analysis on sample 1. Timepoints included baseline, 3 months, 1 year and >5 years. Conversion to surgery was extracted from patient records and was analyzed using a Kaplan Meier survival analysis on sample 2.

Results: A total of 170 participants were included in sample 1 and the median follow-up time was 6.6 years (range 5.1-8.7 years). For the MHQ subscales pain and ADL a mean difference of respectively 17.9 and 13.4 points between baseline and >5 years is present. Conversion to surgery was studied of 465 patients in sample 2 and we found a conversion rate of 16.3 % after a median follow-up of 7.0 years (range 5.5-9.2 years).

Conclusion and key findings: We found positive outcomes at >5 year follow-up for nonsurgical treatment of CMC-1 OA. Moreover, only 16% required additional surgical treatment. Our findings support non-surgical treatment as a first treatment option and suggest that treatment effects are sustainable, although this should be confirmed in a standardized setting such as a randomized controlled trial.

Keywords: osteoarthritis, carpometacarpal, thumb, conservative treatment, orthotic devices,

INTRODUCTION

Osteoarthritis (OA) of the thumb carpometacarpal (CMC-1) is a common hand disorder with a symptomatic prevalence of 7% for females and 2% for males aged over 50 years and a radiographic prevalence of respectively 7.3% and 5.8%(1–3). Because of the aging population, it is expected that the number of patients with CMC-1 OA will increase over time(3,4). CMC-1 OA often results in pain, limitations in activities of daily life (ADL), reduced quality of life, thenar muscle wasting and/or thumb deformity(1,2).

Current treatment guidelines for CMC-1 OA advise starting with non-surgical treatment(5–7). When non-surgical treatment such as immobilization of the CMC-1 with an orthosis, intra-articular steroid injections, analgesics, exercise therapy or a combination of treatments fails to provide enough pain relief or functional improvement in daily life, a decision may be made to proceed to surgical treatment(7–9).

There is evidence that the combination of exercise therapy and the use of orthotics will result in a decrease of pain and increase of function, but unfortunately long-term effects are unknown(7,10–12). This is especially problematic because analgesics, intra-articular injections and orthotics may only provide short-term pain relief, while exercise therapy aims to provide long-term solutions(7,10,13–15). Exercise therapy aims to improve the stability of the unstable CMC-1 by positioning the joint into a more stable situation with reduced joint loading and controlling this stable position with the thenar muscles during ADL. However, the outcomes of the combination of exercise therapy and orthotics are only studied with a follow-up of one year. Knowing that OA is a chronic and degenerative condition, knowledge of long-term outcomes is of utmost importance. Furthermore, while guidelines advise to start with non-surgical treatment to potentially avoid surgery, the actual conversion to surgery has hardly been described. Only a few studies report conversion to surgery, but with a moderate follow-up period of around two years (11,16,17). Avoiding surgery is important, since apart from a long rehabilitation, the results are not always to the patients' satisfaction(18). It is also important to know which patients are most likely to convert to surgery, to be able to make a faster, well-founded decision between starting exercise therapy or choosing directly for surgery.

Therefore, the aim of this study is to describe the outcome of non-surgical treatment, consisting of exercise therapy and the use of orthotics, on patient reported pain and limitations in ADL in patients with CMC-1 OA after at least 5 year follow-up. In addition, conversion to surgery will be described and explored further by investigating if baseline variables such as sex, age, symptom duration, pain at baseline, and limitations in ADL can predict the conversion to surgery after at least 5 year follow-up. Also, patient satisfaction and quality of life will be described after at least 5 year follow-up.

METHODS

Study Design

This is a multicenter, prospective cohort study with observational data reported following the STROBE statement(19).

Setting

Data were collected at Xpert Clinics, a specialized hand clinic in the Netherlands with, at the time, 8 locations and 18 hand surgeons. Outcomes were routinely measured using GemsTracker electronic data capture tools, a secure web-based application for distributing questionnaires and forms of which details have been published earlier(10,11,20). At Xpert Clinics, each patient is assigned a standardized measurement track based on their diagnosis which includes patient reported questionnaires on different domains and timepoints. For some diagnoses, therapist reported measurements have been added (e.g. range of motion or strength).

Participants

All patients were diagnosed with CMC-1 OA in one or both hands by the hand surgeons based on presented symptoms and physical examination and were referred for hand therapy between January 2011 and October 2015. X-rays were not taken by default, but based on preference and insight of the hand surgeons. Patients who completed the Visual Analogue Scale (VAS) and Michigan Hand Outcomes Questionnaire (MHQ) at baseline and three months as part of the routine measurement track, were asked to participate in this follow-up study. Inclusion criteria were that patients had to be over 18 years of age, diagnosed with CMC-1 OA by the hand surgeon, had complete sociodemographic at baseline and had a completed MHQ at timepoints baseline and 3 months. Exclusion criteria were insufficient ability to understand written Dutch language, previous CMC-1 surgery, post-traumatic OA and receiving a corticosteroid injection within the last 6 weeks prior to treatment. Also, patients with active triggerfingers, carpal tunnel syndrome, OA of the interphalangeal joints or De Quervain tenosynovitis that were treated simultaneously with the treatment for their CMC-1 OA were excluded. Information about these possible exclusion criteria were extracted from patient records.

For this study two samples were created. For studying the patient reported pain and limitations in ADL at >5 years, patients that meet the inclusion and exclusion criteria, who were not operated and who completed the MHQ at >5 years are included in sample 1. The data of all patients that meet the inclusion and exclusion criteria were used for analyzing

conversion to surgery and are included in sample 2.

Intervention

The treatment was carried out by more than 40 hand therapists from Xpert Handtherapie, which are specialized hand therapy clinics located in or near an Xpert Clinics, all of whom received the same training on how to treat CMC-1 OA. Treatment was based on the organizations' treatment guideline and the Dutch treatment guideline, which in general consisted of using a custom-made or prefabricated orthosis, one session of 25 minutes of exercise therapy a week and daily exercises(5). Treatment consists of two phases. Phase one (until week 6) included instructions on wearing the orthosis 24 hours a day if possible and exercise therapy for optimizing thumb position by performing coordinative and isometric exercises for the m. Extensor Pollicis Brevis, m. Abductor Pollicis Brevis, m. Abductor Pollicis Longus, m. Opponens Pollicis and m. Flexor Pollicis Brevis. Phase two (week 7 till 12) included reducing the use of the orthosis, and exercise therapy focused on using the taught stable position of the thumb during daily activities and improving thenar strength. The amount of sessions were planned by judgement of the therapist and availability of the patient and thus could vary between patients due to the observational nature of this study.

Measurements

Baseline demographics of all patients, including sex, age, type of work, dominance, affected hand and symptom duration, were extracted from patients records before start of the treatment.

Pain and limitations in ADL were routinely measured with the MHQ subscale pain and subscale ADL at the start of the treatment, and at 3 months and 1 year. For the purpose of this study an additional timepoint was added at >5 years. The MHQ is a widely used questionnaire for measuring hand function with high internal consistency and validity and with acceptable reliability(21). It consists of 37 items divided into six subscales: overall hand function, activities in daily living (ADL), pain, work performance, aesthetics and patient satisfaction with hand function(21,22). Items are scored on a 5-point Likert scale and raw scores are converted to a 0-100 scale according to a scoring algorithm. Higher scores indicate better performance in all subscales except pain. We converted the subscale pain for ease of interpretation, thus higher score indicated better performance for all subscales. The MHQ total score has a minimal clinically important difference (MCID) of 8-13 points, the subscale pain and ADL have an MCID of 14.4 points and 10.9 points respectively(23,24).

Health-related Quality of Life (QoL) was measured only at timepoint >5 years by the 5-level EuroQol-5 Dimension (EQ-5D-5L), which is the most widely used tool to describe QoL(25). Scores of the EQ-5D-index are anchored at 1 (full health) and 0 (a state as bad as being

dead). Values less than 0 represent health states regarded as worse than a state that is as bad as being dead(25). Investigations of the measurement properties in patients with disorders of the upper extremities are rare, but indicate good reliability and validity as well as moderate responsiveness(26).

Patient-satisfaction with the treatment results was measured by a questionnaire with high reliability in which patients were asked how satisfied they were on a 5-point Likert scale, and if they would undergo this treatment again(27).

Conversion to surgery data were extracted from patient records and a generic questionnaire about the use of any other hand-therapeutic or hand-surgical treatments.

Study size

Sample size was estimated based on a repeated measures design with two primary outcomes; pain and limitations in ADL. Power analysis with a conventional effect size of 0.25 (as defined by Cohen(28)), alpha=0.025 due Bonferonni correction and a Power of 0.80, indicated that a sample size of 49 participants was required. This was well below the achieved sample of 170.

Statistical analysis

A non-responder analysis was performed using t-tests and chi-squared tests on demographic characteristics, baseline primary outcomes, and primary outcomes at 3 months to compare participants who responded to the call to fill in an additional MHQ at timepoint >5 years (defined as responders) with the participants who did not fill in the MHQ at >5 years (defined as non-responders).

Pain and limitations in ADL were analyzed separately using linear mixed models, using the MHQ subscale pain and the MHQ subscale ADL at >5 years as dependent variable and timepoint as fixed factor. The other subscales of the MHQ were also analyzed using linear mixed models and reported as secondary outcomes. Assumptions were checked using residual plots and normal probability plots. Missing values at timepoint 12 months were analyzed by performing a Little's test to assess the assumption completely at random(29,30). Additionally, a non-responder analysis similar to the non-responder analysis on outcomes at timepoint >5 years was performed on demographic characteristics, baseline primary outcomes, and primary outcomes at 3 months for outcomes at timepoint 12 months.
As a secondary analysis we also reported the outcomes of the MHQ of all patients, even the ones with missing data (possible because of conversion to surgery), analyzed using linear mixed models, using the outcomes of the MHQ as dependent variable and timepoint as fixed factor (31). This to see whether the first model does not make too positive estimates because

sample 1 only contains patients who did not convert to surgery.

QoL was only available at timepoint >5 years, thus outcomes on QoL were only described by displaying the median and range of the EQ5D-index score.

Patient-satisfaction on treatment outcomes is reported by displaying the answers the patients gave on the 5-point Likert scale, and the percentage of patient who responded with 'yes' on the question if they would undergo this treatment again.

Conversion to surgery was analyzed using a Kaplan Meier survival analysis. We used a survival curve to display the time in months before deciding to convert to surgery and report the proportion of patients who underwent a surgical procedure for CMC-1 OA. Binary logistic regression was used to investigate which baseline variables can predict the conversion to surgery after >5 years. Baseline variables used were; sex, age, duration of symptoms, pain at baseline (measured with the MHQ subscale pain) and limitations in ADL at baseline (measured with the MHQ subscale ADL). Assumptions were checked using variance inflation factor (VIF) with its cut-off value at 10 and scatter plots between each predictor and the logit value(32,33).

All analyses were performed using R project for statistical computing (version 4.0.3) and RStudio (version 1.4.1103).

RESULTS

In total 552 measurement tracks of 550 patients were screened for eligibility. After applying the exclusion criteria, 465 patients remained (see figure 1). To study pain and function at >5 years, patients converted to surgery were excluded and of the 389 patients that remained, 170 patients completed the questionnaires at timepoint >5 years (sample 1). To study conversion to surgery, all 465 patients who met the inclusion and exclusion criteria were included (sample 2). Baseline characteristics of both samples are depicted in table 1.

Figure 1. *Flowchart of the study*

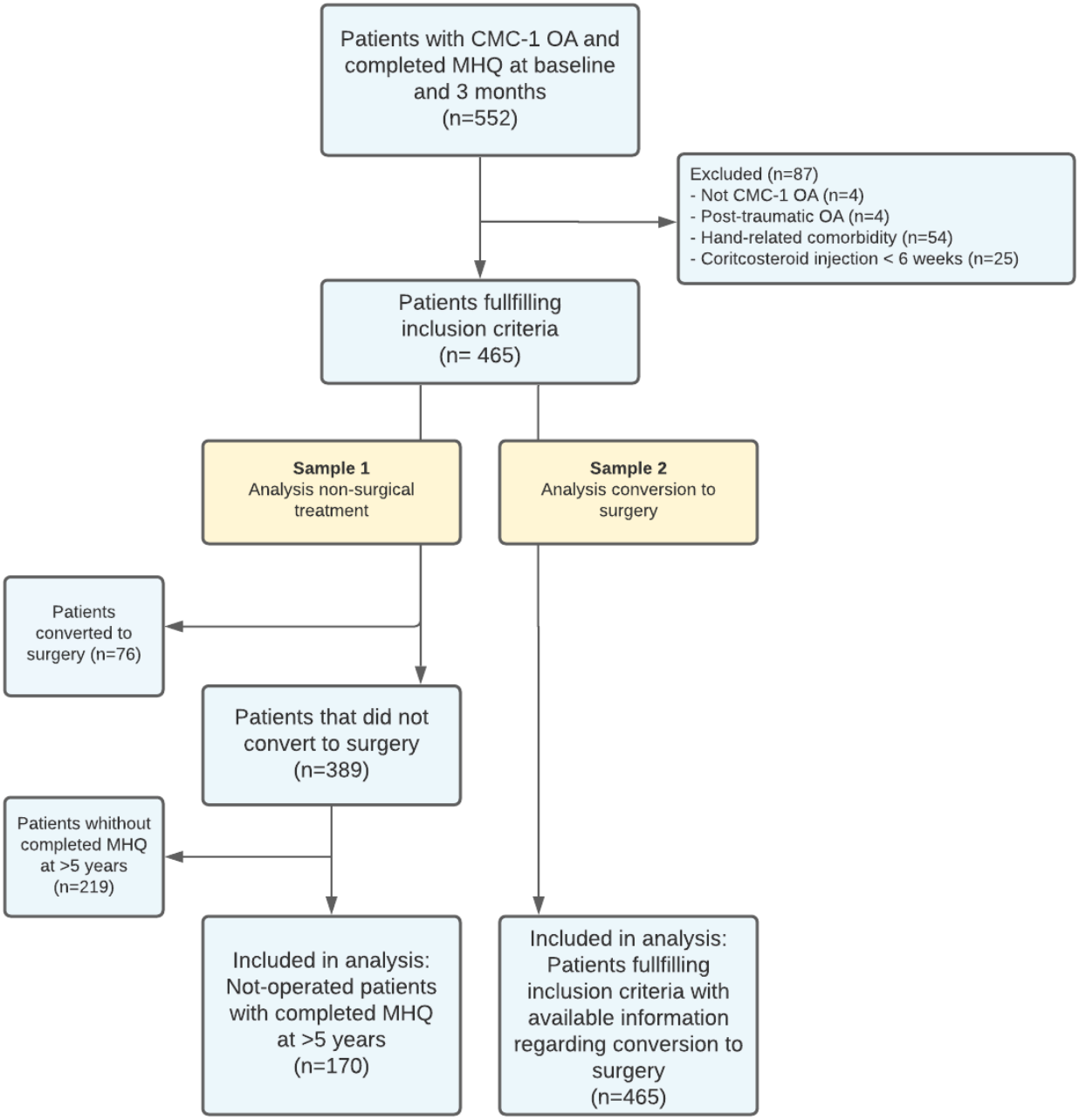

Table 1. *Baseline characteristics.*

Variables		**Sample 1 (N=170)**	**Sample 2 (N=465)**
Age, mean ± SD		59.2 ± 7.8	59.7 ± 8.5
Sex, %	Female	75.9	77.6
Symptom duration (months), median [Q1-Q3]		12 [6 – 36]	12 [6 – 36]
Dominant hand, %	Left	8.2	8.4
	Right	86.5	87.5
	Both	5.3	4.1
Treated hand, %	Left	56.5	49.2
	Right	43.5	50.8
Type of work, %	Unemployed	41.2	42.4
	Light physical work	21.8	24.1
	Moderate physical work	24.1	22.6
	Heavy physical work	12.9	11.2
Michigan Hand Outcomes Questionnaire at baseline, mean ± SD	Total score	60.9 ± 14.0	58.4 ± 14.2
	ADL score	68.5 ± 19.2	64.7 ± 19.5
	Pain score	48.5 ± 16.2	46.3 ± 17.1
	Function score	57.7 ± 14.9	55.7 ± 15.4
	Esthetics score	83.5 ± 19.9	81.9 ± 20.2
	Satisfaction score	44.4 ± 22.1	41.3 ± 21.0
	Work score	62.8 ± 24.5	60.3 ± 24.5

The non-responder analysis performed on demographic characteristics, baseline primary outcomes, and primary outcomes at 3 months, indicated that at >5 years and 12 months respectively only one of twenty-one and two of twenty-one variables differed between responders and non-responders (see supplementary table 1 and 2). A non-significant Little's test (p=0.175) suggests that they are missing completely at random(29,30).

Patient reported pain and limitations in ADL

Sample 1 was used for the primary analysis of patient-reported pain and limitations in ADL. The completed MHQ of this sample at timepoint >5 years has a median follow-up time of 6.6 years (range 5.1 – 8.7 years). The outcomes of the MHQ on timepoint 12 months were missing in 21% (n=36) of the cases. For the other timepoints all 170 participants completed the questionnaire.

Figure 2 demonstrates the course of the mean of the MHQ subscales ADL and pain over time of sample 1. Most improvement takes place in the first three months after starting non-surgical treatment.

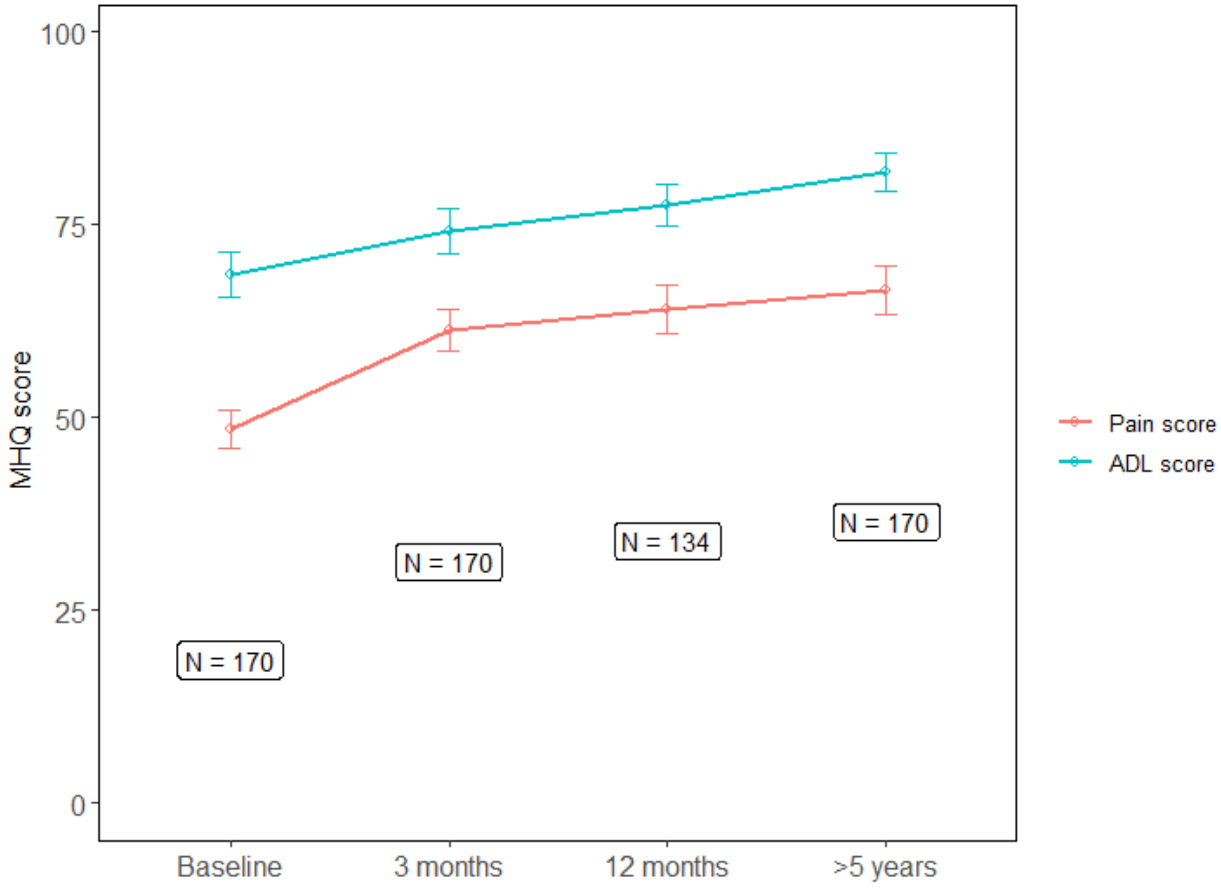

Figure 2. *Course of the mean score of the Michigan Hand Outcomes Questionnaire (MHQ) subscales pain and ADL. Most improvement is seen in the first three months.*

We found a significant mean difference of 17.9 points (p =<0.0001) between baseline and >5 years for the MHQ subscale pain(see table 2). For the MHQ subscale ADL a significant mean difference of 13.4 points (p=<0.0001) between baseline and >5 years is present (see table 2). Furthermore, for the subscale ADL there is a significant mean improvement of 4.4 points (p=0.0137) between timepoint 12 months and >5 years. The subscale overall hand function, patient satisfaction with hand function, work performance and the total score also show a significant improvement at timepoint > 5 years (see table 2).

The secondary analysis of the outcomes of the MHQ of all patients, even the ones with missing data (possible because of conversion to surgery), also shows significant improvements between baseline and >5 years in the MHQ subscales pain and ADL of 17.8 point (p=<0.0001) and 14.5 points (p=<0.0001) respectively (see supplementary table 3).

Table 2. *Outcomes for the Michigan Hand Outcomes Questionnaire (MHQ) total score and different subscales (score range 0-100, higher scores indicate better function and less pain) of sample 1. Significance testing was performed using linear mixed model analysis. Δ shows the models' estimated marginal mean difference between the given timepoints. * indicates a significant p-value (<0.025) .*

Variable	**Baseline, mean ± SD**	**3 months, mean ± SD**	**12 months, mean ± SD**	**>5 years, mean ± SD**
MHQ Total score	60.9 ± 14.0	69.7 ± 15.1	70.9 ± 15.3	75.0 ± 14.7
MHQ ADL score	***68.5 ± 19.2***	***74.1 ± 19.3***	***77.5 ± 16.3***	***81.8 ± 16.3***
MHQ Pain score	***48.5 ± 16.2***	***61.2 ± 18.2***	***63.7 ± 18.4***	***66.4 ± 21.1***
MHQ Function score	57.7 ± 14.9	61.8 ± 14.4	62.8 ± 14.5	67.4 ± 14.8
MHQ Esthetics score	83.5 ± 19.9	88.0 ± 15.7	85.3 ± 19.1	87.9 ± 17.6
MHQ Satisfaction score	44.4 ± 22.1	63.4 ± 24.5	63.2 ± 25.2	67.4 ± 26.0
MHQ Work score	62.8 ± 24.6	69.6 ± 23.4	72.6 ± 23.1	78.9 ± 21.6

Variable	**Δ baseline-3 mo**	**P-value**	**Δ baseline-12 mo**	**P-value**	**Δ baseline->5 years**	**P-value**	**Δ 3 mo-12 mo**	**P-value**	**Δ 3 mo->5 years**	**P-value**	**Δ 12 mo–>5 years**	**P-value**
MHQ Total score	8.8	**<0.0001***	10.0	**<0.0001***	14.1	**<0.0001***	1.2	0.7598	5.3	**<0.0001***	4.2	**0.0033***
MHQ ADL score	*5.6*	***0.0002****	*9.0*	***<0.0001****	*13.4*	***<0.0001****	*3.4*	*0.0866*	*7.8*	***<0.0001****	*4.4*	***0.0137****
MHQ Pain score	*12.7*	***<0.0001****	*15.2*	***<0.0001****	*17.9*	***<0.0001****	*2.5*	*0.4272*	*5.2*	***0.0039****	*2.7*	*0.3565*
MHQ Function score	4.1	**0.0070***	5.1	**0.0011***	9.7	**<0.0001***	1.0	0.8752	5.7	**<0.0001***	4.6	**0.0037***
MHQ Esthetics score	4.5	**0.0210***	1.8	0.6896	4.4	0.0259	- 2.6	0.3920	- 0.1	0.9999	2.5	0.4308
MHQ Satisfaction score	18.9	**<0.0001***	18.7	**<0.0001***	23.0	**<0.0001***	- 0.2	0.9997	4.1	0.1904	4.3	0.2118
MHQ Work score	6.8	**0.0029***	9.8	**<0.0001***	16.1	**<0.0001***	3.0	0.4803	9.3	**<0.0001***	6.3	**0.0150***

Patient satisfaction and quality of life

Of the 163 participants who completed the questionnaire about their satisfaction with the treatment results, 5% responded with 'poor', 14% with 'moderate', 26% with 'fair', 39% with 'good' and 16% with 'excellent'. On the question about the willingness to undergo treatment again, 71.2 % of patients responded with 'yes'.
Concerning the QoL the median EQ-5D-index is 0.852 (range 0.135- 1).

Conversion to surgery

Figure 3 shows the survival curve for conversion to surgery, demonstrating that after a median follow-up of 7.0 years (range 5.5 – 9.2), 76 participants (16.3%) converted to surgery. The median time to make the decision to convert to surgery was 4.7 months (range 0.7 - 82.7) after the start of non-surgical treatment.

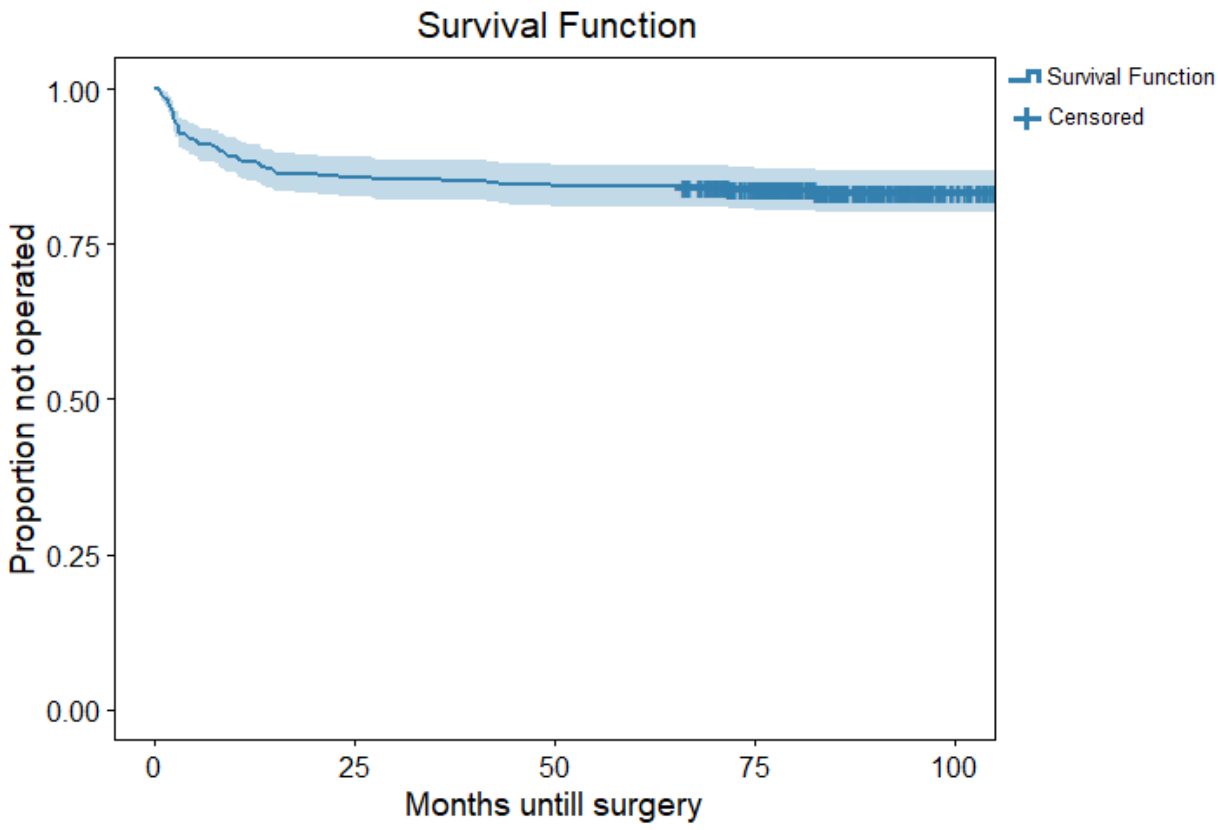

***Figure 3**. The blue line of the survival curve displays the proportion of patients converted to surgery and the time in months before deciding to convert to surgery. After a median follow-up time of 7.0 years, 16.3% decided to convert to surgery. The median time to decide to convert to surgery was 4.7 months. The light blue space shows the confidence interval. Censoring means that the patient did not convert to surgery at the time of conducting this study.*

Binary logistic regression shows that of the variables; sex, age, symptom duration, pain at baseline (MHQ subscale pain), and limitations in ADL at baseline (MHQ subscale ADL), only pain at baseline has an influence (p= <0.001) on converting to surgery with an odds ratio of 0.96 (Confidence Interval 0.94-0.98)(see figure 4). The model has an AUC of 0.738. Mean score at baseline of MHQ subscale pain was 35.72 (± 13.33) for patients who converted to surgery and 48.37 (±16.96) for patients who did not convert to surgery.

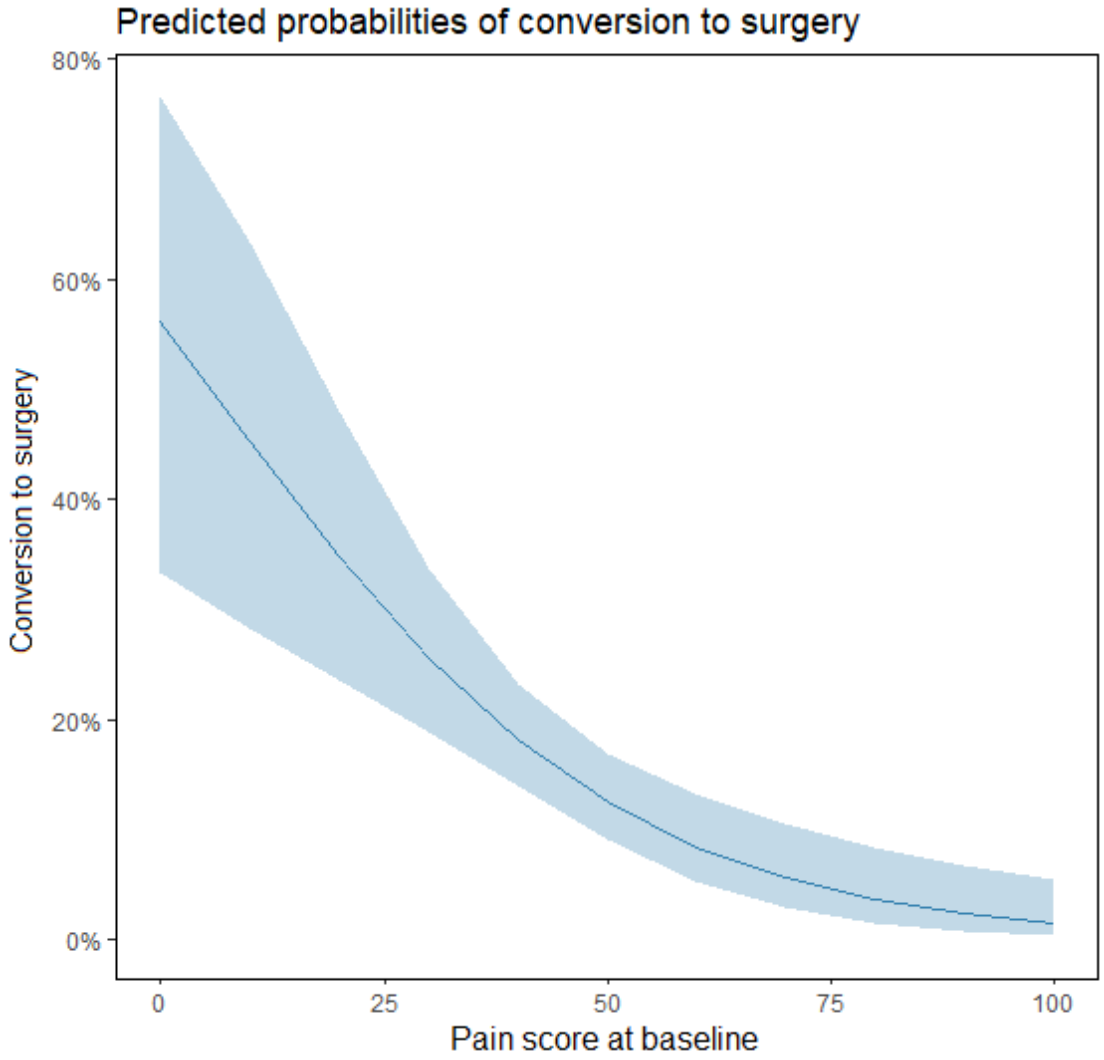

Figure 4. *Predicted values for conversion to surgery based on pain score at baseline, measured with the Michigan Hand Outcomes Questionnaire subscale pain with the score of subscale pain on the x-axis and the predicted probability on converting to surgery on the y-axis.*

DISCUSSION

We found clinically relevant improvements on patient reported pain and limitations in ADL after at least 5 year follow-up in patients with CMC-1 OA following non-surgical treatment, consisting of exercise therapy and the use of orthotics. Only 16.3% converted to surgery after a median follow-up of 7.0 years and pain at baseline seems to have an influence in converting to surgery, suggesting that patients with worse pain at baseline scores are more likely to convert to surgery. These outcomes suggest that despite having a degenerative disease, the treatment effects seem lasting and that exercise therapy and the use of orthotics seem a sustainable solution for CMC-1 OA.

Being the first study with a long-term follow-up, the current study gives insights in the course of pain and limitations in ADL up to a median follow-up time of 6.6 years. Even though most improvement is seen during the active treatment period of the first three months, there is also improvement seen after three months and even after 12 months. Something that we did not know before, based on earlier studies that only show short-term benefits(7). Such as the study of O'Brien et al., which shows that in a small sample cohort (n=35), pain significantly and clinically relevant decreased in patients with CMC-1 OA after a maximum follow-up of 90 days(15). Or as the randomized controlled trial of Deveza et al. which states a small to medium effect after a combined treatment with the addition of exercises and orthoses over education and ergonomic principles alone with a follow-up of 12 weeks(34). We also did not fully expect these lasting improvements, based on earlier studies on for example knee and hip osteoarthritis, which showed no long-term effectiveness of exercise therapy on pain(35). A possible explanation for the lasting improvements could be that apart from only strengthening the thenar muscles, exercise therapy is aimed at using a new and more stable position of the thumb. Patients learn how to minimize pain by using this position and therefore to cope with their OA. This in combination with possible continuation of the orthosis during heavy load activities could perhaps lead to longer lasting outcomes.

Contrary to the lasting improvements that are seen, not everyone sufficiently benefits from therapy, e.g. the 16.3% we found in this study who eventually converted to surgery. The proportion of patients who converted that we found in our study, is similar to the ones found in earlier studies, but with a much longer follow-up. A study of Tsehaie et al. found a conversion rate of 15.3% after treatment with a hand orthosis and exercise therapy after a mean follow-up of 2.2 years(11). A study of Gravas et al. reports that during a randomized controlled trial, 24% of patients who received occupational therapy, underwent surgery after a follow-up of 2 years(16). A third study, from Schloemann et al., reports conversion to surgery of 9% after non-surgical treatment with a median follow-up of 1.5 years(17). Because of the similar percentages, but the longer follow-up of the current study, the results of this study suggest that even with a long-term follow-up, few people are operated on. That also

suggests a relatively long-term treatment effect.
In our prediction model only pain at baseline seems to have an influence on converting to surgery, which is insufficient information to make a well-founded decision between starting exercise therapy in combination with orthotics or choosing directly for surgery. Earlier studies found that the variables pain improvement, patients' prior surgical experience, surgeons' attitudes toward CMC-1 OA, previous non-pharmacological treatment, and higher motivation for surgery seem to have an influence(11,16,17). Predicting conversion to surgery could be improved by also taking the psychological characteristics into account as an earlier study found that patients scheduled for non-surgical treatment have a worse psychological profile that those scheduled for non-surgical treatment(36).

The outcome regarding quality of life (QoL) as a standalone outcome, does not give a reflection of the given treatment because no difference score was calculated. However, since QoL is an underexposed part of outcomes in this patient population, this outcome could be of added value for future research(37,38). When compared to patient groups such as patients with knee or hip osteoarthritis, the EQ-5D-index-score found in the current study seems higher(39).

Study limitations

A limitation of this study is the missing data due to the observational nature of this study. Not all eligible patients filled in the questionnaires at timepoint >5 years. Another limitation is that the outcomes only represent the patients who did not convert to surgery and therefore the model could be more positive than it actually is. To address this point we did a secondary analysis on the entire sample, even the ones with missing data (possible because of conversion to surgery), which showed similar improvements.

Secondly, another limitation of the observational nature of this study is that we can not suggest true causality. Oppositely, there is a higher natural validity as the given treatment reflects daily practice. Although, therapists are trained the same, there certainly could be differences among therapists and patients in the amount of exercise therapy given or the amount of exercises performed. Therapy was given by judgement of the therapist and availability of the patient, but possible costs or traveling distance could influence this. The possible variation of the treatment is important to acknowledge, because study shows that exercises have a relatively large treatment effect compared to using an orthosis alone(10).

Furthermore, information concerning conversion to surgery was extracted from patient records. It is possible that patients had surgery elsewhere without knowledge of the treating hand surgeon and therefore are not included in the analyses.

CONCLUSION

We found positive outcomes at >5 year follow-up for non-surgical treatment of CMC-1 OA consisting of exercise therapy and the use of orthotics. Moreover, only 16% required additional surgical treatment. Our findings support non-surgical treatment as a first treatment option and suggest that treatment effects are sustainable, although this should be confirmed in a standardized setting such as a randomized controlled trial where the specific role of exercise therapy in addition to orthoses should also be investigated.

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APPENDIX. Supplementary tables

Supplementary table 1. *Non-responder analysis on demographic characteristics, baseline primary outcomes, and primary outcomes at 3 months to compare participants with and without the presence of the MHQ at timepoint >5 years. * indicates a significant p-value (p= <0.05).*

Variables		**Non-responder (N=248)**	**Responder (N=217)**	**p-value**
Age, mean ±SD		60.4 ± 8.9	58.8 ± 7.9	**0.039***
Sex, %	Female	76.2	79.3	0.499
Symptom duration (months), median [Q1-Q3]		12 [6-36]	12 [6-36]	0.448
Dominant hand, %	Left	8.1	8.8	0.962
	Right	87.9	87.1	
	Both	4.0	4.1	
Treated hand, %	Left	46.4	52.5	0.217
	Right	53.6	47.5	
Type of work, %	Unemployed	45.6	38.2	0.320
	Light physical work	24.2	24.0	
	Moderate physical work	20.6	24.9	
	Heavy physical work	9.7	12.9	
Second opinion, %	Yes	4.8	5.1	1.000
Michigan Hand Outcomes Questionnaire at baseline, mean ± SD	Total score	57.9 ± 14.4	58.9 ± 14.0	0.444
	ADL score	64.0 ± 19.2	65.5 ± 19.9	0.400
	Pain score	46.7 ± 17.7	45.9 ± 16.3	0.635
	Function score	54.9 ± 15.6	56.7 ±15.2	0.220
	Esthetics score	81.3 ± 20.6	82.7 ± 19.9	0.436
	Satisfaction score	40.7 ± 20.3	42.0 ± 21.7	0.517
	Work score	59.9 ± 24.2	60.7 ± 24.9	0.721
Michigan Hand Outcomes Questionnaire at 3 months, mean ± SD	Total score	65.5 ±16.1	66.1 ± 16.5	0.711
	ADL score	70.2 ± 19.6	69.8 ± 21.6	0.832
	Pain score	56.5 ± 20.0	57.3 ± 19.4	0.641
	Function score	58.8 ± 15.8	59.5 ±14.9	0.592
	Esthetics score	82.7 ± 21.9	86.2 ± 17.0	0.058
	Satisfaction score	58.0 ± 25.5	58.4 ± 25.7	0.868
	Work score	67.0 ± 25.7	65.3 ± 25.7	0.467

***Supplementary table 2**. Non-responder analysis on demographic characteristics, baseline primary outcomes, and primary outcomes at 3 months to compare participants with and without the presence of the MHQ at timepoint 12 months. * indicates a significant p-value (p= <0.05).*

Variables		**Non-responder (N=36)**	**Responder (N=134)**	**p-value**
Age, mean ±SD		56.5 ± 8.02	59.9 ± 7.7	**0.021***
Sex, %	Female	80.6	74.6	0.604
Symptom duration (months), median [Q1-Q3]		12 [6-24]	12 [6-36]	0.241
Dominant hand, %	Left	5.6	9.0	0.805
	Right	88.9	85.8	
	Both	5.6	5.2	
Treated hand, %	Left	61.1	55.2	0.658
	Right	38.9	44.8	
Type of work, %	Unemployed	25.0	45.5	**0.027***
	Light physical work	33.3	18.7	
	Moderate physical work	19.4	25.4	
	Heavy physical work	22.2	10.4	
Second opinion, %	Yes	8.3	3.7	0.475
Michigan Hand Outcomes Questionnaire at baseline, mean ± SD	Total score	61.3 ± 11.5	60.8 ± 14.6	0.842
	ADL score	67.7 ± 20.3	68.7 ± 19.0	0.780
	Pain score	48.6 ± 13.3	48.5 ± 17.0	0.963
	Function score	57.8 ± 14.7	57.7 ± 15.0	0.985
	Esthetics score	87.3 ± 16.8	82.5 ± 20.6	0.194
	Satisfaction score	41.1 ± 17.7	45.3 ± 23.1	0.311
	Work score	65.4 ± 26.1	62.1 ± 24.2	0.472
Michigan Hand Outcomes Questionnaire at 3 months, mean ± SD	Total score	68.3 ± 12.4	70.0 ± 15.8	0.547
	ADL score	71.5 ± 17.8	74.8 ±19.7	0.361
	Pain score	59.2 ± 17.7	61.8 ± 18.4	0.444
	Function score	59.9 ±10.4	62.3 ±15.3	0.365
	Esthetics score	90.1 ± 13.6	87.4 ± 16.3	0.363
	Satisfaction score	57.4 ± 19.9	65.0 ± 25.4	0.444
	Work score	71.9 ± 19.7	69.0 ± 24.3	0.503

***Supplementary table 3**. Outcomes for the Michigan Hand Outcomes Questionnaire (MHQ) total score and different subscales (score range 0-100, higher scores indicate better function and less pain) of sample 2. Significance testing was performed using linear mixed model analysis. Δ shows te models' estimated marginal mean difference between the given timepoints. * indicates a significant p-value (<0.025).*

Variable	**Baseline, mean ± SD**	**3 months, mean ± SD**	**12 months, mean ± SD**	**>5 years, mean ± SD**
MHQ Total score	58.4 ± 14.2	65.8 ± 16.2	68.0 ± 16.0	75.0 ± 14.7
MHQ ADL score	***64.7*** ± 19.5	***70.0*** ± 20.5	***74.8*** ± 17.4	***81.8*** ± 16.3
MHQ Pain score	***46.3*** ± 17.1	***56.9*** ± 19.7	***60.6*** ± 19.3	***66.4*** ± 21.1
MHQ Function score	55.7 ± 15.4	59.1 ± 15.4	61.5 ± 15.7	67.4 ± 14.8
MHQ Esthetics score	81.9 ± 20.2	84.4 ± 19.8	83.3 ± 21.0	87.9 ± 17.6
MHQ Satisfaction score	41.3 ± 21.0	58.2 ± 25.6	58.3 ± 26.5	66.4 ± 21.1
MHQ Work score	60.3 ± 24.5	66.2 ± 25.7	69.0 ± 25.6	78.9 ± 21.6

Variable	**Δ baseline-3 mo**	**P-value**	**Δ baseline-12 mo**	**P-value**	**Δ baseline->5 years**	**P-value**	**Δ 3 mo-12 mo**	**P-value**	**Δ 3 mo->5 years**	**P-value**	**Δ 12 mo–>5 years**	**P-value**
MHQ Total score	7.5	**<0.0001***	9.8	**<0.0001***	14.3	**<0.0001***	2.3	0.0256	6.9	**<0.0001***	4.5	**0.0002***
MHQ ADL score	*5.3*	***<0.0001****	*10.2*	***<0.0001****	*14.5*	***<0.0001****	*4.9*	***<0.0001****	*9.2*	***<0.0001****	*4.3*	***0.0103****
MHQ Pain score	*10.6*	***<0.0001****	*14.3*	***<0.0001****	*17.8*	***<0.0001****	*3.7*	***0.0041****	*7.2*	***<0.0001****	*3.6*	*0.0610*
MHQ Function score	3.4	**0.0001***	6.0	**<0.0001***	10.5	**<0.0001***	2.6	0.289	7.1	**<0.0001***	4.4	**0.0019***
MHQ Esthetics score	2.5	0.0642	2.0	0.3173	4.4	**0.0121***	- 0.4	0.9823	1.9	0.5316	2.4	0.4131
MHQ Satisfaction score	17.0	**<0.0001***	17.3	**<0.0001***	23.4	**<0.0001***	0.4	0.9952	6.5	**0.0020***	6.1	**0.0088***
MHQ Work score	6.0	**<0.0001***	8.9	**<0.0001***	16.5	**<0.0001***	3.0	0.1581	10.5	**<0.0001***	7.5	**0.0003***