Original Research

Response to Conservative Treatment for Thumb Carpometacarpal Osteoarthritis Is Associated With Conversion to Surgery: A Prospective Cohort Study

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Background. The current guidelines for treatment of carpometacarpal osteoarthritis recommend starting with conservative treatment before a surgical procedure is considered.

Objective. The objective was to investigate how response to conservative treatment, in terms of pain and hand function, influences the hazard that patients convert to surgical treatment.

Design. This was a multicenter, prospective cohort study.

Methods. Participants comprised 701 patients who received 3 months of hand therapy and an orthosis. Pain and function were measured with the Michigan Hand Questionnaire (MHQ) at baseline and at 6 weeks and 3 months follow-up. Conversion to surgical treatment was recorded from clinical records. Joint modeling (a statistical method of combining prediction models) was used to perform the analysis and to calculate hazard ratios (HRs).

Results. The joint analytical model showed that both MHQ pain score at a certain point (HR = 0.93; 95% confidence interval [CI] = 0.92–0.94) and change in MHQ pain score (HR = 1.07; 95% CI = 1.06–1.09) during conservative treatment was significantly associated with conversion to surgical treatment. The joint analytical model between functional outcome and conversion to surgical treatment showed only a significant association between MHQ function at a certain point (HR = 0.97; 95% CI = 0.95–0.99), and no significant association between the change in MHQ score for function (HR = 1.0; 95% CI = 1.0–1.0) and conversion to surgical treatment.

Limitations. Missing data might have resulted in biased estimates.

Conclusions. Self-reported pain and function, as well as change in self-reported pain during treatment, were associated with the hazard of conversion to surgical treatment, whereas change in self-reported functioning was not associated with conversion. Because a reduction in pain during conservative treatment appears to decrease the rate of conversion to surgical treatment, it is advised to structurally monitor pain levels during treatment.

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For symptomatic carpometacarpal (CMC) osteoarthritis (OA) of the thumb, treatment guidelines recommend starting with conservative treatment.[1–4] The suggested treatments include—either in or not in combination with topical or oral nonsteroidal anti-inflammatory drugs—analgesics, hand therapy, an orthosis, or intra-articular steroid injection.[5–7] When the patient experiences insufficient pain relief or functional improvement after conservative treatment, the surgeon and patient might opt for surgical treatment.

After hand therapy and an orthosis, considerable variation has been found in outcomes, that is, some patients report substantial pain relief and functional improvement whereas others experience no improvement or even a deterioration.[8–10] Although the primary goal of conservative treatment for CMC-1 is to reduce pain and improve function, an indirect goal is to avoid surgical intervention. The decision to undergo elective surgical treatment is based on many factors, including treatment guidelines, scientific evidence, and patient characteristics and, in contrast to nonelective surgical treatment, patient and surgeon preferences are likely to play an important role. Therefore, it is important to assess the extent to which this decision is based on quantifiable improvement in pain and function, as recorded during the conservative treatment.

Therefore, the aim of the present study was to investigate the relationship between pain and hand function in patients with CMC OA, at the start, during, and end of conservative treatment, and the hazard of converting to surgical treatment.

Methods

Study Design and Setting

This prospective cohort study was conducted between January 2011 and November 2014 at Xpert Clinic in the Netherlands. Xpert Clinic is an outpatient treatment center specializing in treating hand and wrist problems; it has 17 different locations, 16 European Board certified Federation of European Societies for Surgery of the Hand (FESSH) hand surgeons working at the multiple locations, and approximately 140 hand therapists. The study was approved by the local institutional review board and written informed consent was obtained from all participants.

Data were collected during routine clinical care based on the Dutch treatment guideline, which, in case of CMC OA, recommends starting with hand therapy and an orthosis.[1] In general, treatment consisted of prescribing a custom-made or prefabricated butterfly orthosis in which the CMC-1 joint was fixed in extension/abduction, and the metacarpophalangeal joint (MCP-1) fixed in mild flexion (see eFig. 1 and eFig. 2, available at https://academic.oup.com/ptj). The choice of custom-made or prefabricated orthosis was based on the preference of the hand therapist and the terms of the participant's insurance company. In addition, two 25-minute sessions of hand therapy were given per week. However, additional or fewer sessions could be planned based on the therapist's judgment, and the ability and/or availability of the participant.

All hand therapists received the same internal training on how to treat CMC OA with hand therapy. Participants received treatment under the supervision of (generally) the same therapist, using a standardized protocol. Treatment was divided into 2 phases of 6 weeks per phase (ie, total treatment of 3 months).

Phase 1 included instruction on how to wear the orthosis throughout the day, and consisted of hand therapy for correct thumb position (training pinch/grasping movements without hyperextension in the MCP thumb joint, and without CMC adduction) and using a full thumb range of motion (which trains specific coordination of the intrinsic/extrinsic muscles of the thumb).

Phase 2 included instruction to wear the orthosis only during heavy activities, depending on the pain level and the participant's ability to perform activities with a stable thumb position. During this phase, hand therapy focused on improving active stability during daily activities and improving thenar muscle strength. In Phase 2, participants performed home exercises 4 to 6 times a day. The number of prescribed home exercises ranged from 3 to 6 exercises per day, with 10 to 15 repetitions each, depending on the individual participant and the level of pain. After Phase 2, participants were encouraged to keep doing the exercises, and were allowed to use the orthosis when necessary. Corticosteroid injections were not part of the treatment, and no nonsteroidal anti-inflammatory drugs were prescribed.

Participants

All participants in this study were patients diagnosed by a hand surgeon to have primary nontraumatic CMC OA and receiving conservative treatment. Excluded were patients who were previously surgically treated for their CMC OA or were receiving simultaneous treatment for other hand conditions. Patients were also excluded when they received intra-articular corticosteroid injection prior to their treatment, because this might interact with the effectiveness of hand therapy.

Baseline Demographics

Baseline characteristics of all participants (including sex, age, and which hand was treated) were collected before the start of treatment to correct for potential confounding.

Treatment Outcome

To evaluate the outcome of conservative treatment, participants filled out the Michigan Hand Questionnaire

(MHQ; Dutch language version), in which a score of 0 = poorest function/highest pain, and 100 = ideal function/no pain.[11–13] The MHQ is a self-reported questionnaire with 6 domains (pain, aesthetics, hand function, performance of activities of daily living, work performance, and satisfaction) and 37 items. For the present study, the domains "pain" and "hand function" of the MHQ were investigated, because patients with CMC OA mainly have complaints of pain and loss of hand function.[14] The test-retest reliability for MHQ pain is 0.91 and for MHQ hand function is 0.92.[12] The minimum clinically important difference is 11 points for MHQ pain and 13 points for MHQ function.[15] Furthermore, both domains have excellent internal consistency, with a Cronbach α of 0.86 for pain and 0.93 for function.[12] As part of our web-based outcome registration, the MHQ was filled in before the start of conservative treatment (baseline), and again at 6 weeks and 3 months.

Conversion to Surgical Treatment

All participants had a follow-up appointment with their hand surgeon approximately 3 months after the start of therapy. At the follow-up appointment the surgeon, together with the participant, evaluated the effects of the conservative treatment and the current health complaints. Based on this evaluation, surgical treatment was discussed as an option. However, participants could schedule a follow-up appointment before the planned appointment at 3 months when participants did not see any benefit of conservative treatment and opted for surgical treatment.

For participants who underwent surgical treatment after conservative treatment between January 2011 and February 2016, the number of days from the start of conservative treatment until surgical treatment was recorded. We use the term "conversion to surgery" to denote the decision made by surgeon and participant to undergo surgical treatment.

Statistical Methods

To describe the participant-specific course of self-reported pain over time, and account for the correlation in the repeated measurements of each participant, the framework of linear mixed models (LMM) was used. We modeled time as a continuous variable, meaning that we modeled the evolution of outcome in pain and function over time (in days) following a linear pattern.

To examine the association between the response to conservative treatment in terms of self-reported pain and function, and the hazard of conversion to surgery, a joint analytical model was used that combines the longitudinal course obtained from the LMM with a Cox regression model.

Using a standard Cox regression model without using the joint analytical model would be theoretically invalid, because it would assume that change in MHQ pain and function is time independent and constant between the follow-up moments.[16,17] Joint analytical models adjust for the variability between measured MHQ pain and function scores over time.

In the created Cox regression model (which served as input for the joint analytical model) correction was made for the following baseline characteristics: sex, age, and which hand was treated.

Because we were interested not only in the influence on outcome after conservative treatment at a certain time, but also in the influence of change on outcome after conservative treatment between follow-up and relation to surgery, we added a time-dependent slope parameterization to the joint analytical model.

To assess the discriminative ability of the MHQ pain and function scores, internal validation was performed using Monte Carlo simulations. We relied on the receiver operating curve to examine how well the joint analytical model could discriminate between participants who would convert to surgery and participants who would not convert to surgery (up to 2 years later), using the longitudinal development of outcome in pain and function over 3 months of conservative treatment.

For the LMM and Cox regression, the R packages Nlme and Survival were used; for the joint modeling package, JMbayes was used.[18] For all tests, a P value $\leq .05$ was considered to be statistically significant.

Results

Response to Conservative Therapy: Pain and Function

Between January 2012 and November 2014, we included 701 patients diagnosed with CMC OA who received conservative treatment (Figure). Table 1 presents the baseline characteristics and outcome at 6 weeks and 3 months after start of treatment. The figure also shows the response rates at the subsequent follow-up moments. Because missing data could have biased the results, a responder/nonresponder analysis was performed to test whether participants who did not fill in the MHQ at 6 weeks and at 3 months showed differences with regard to baseline characteristics; however, no significant differences were found (eTable, available at https://academic.oup.com/ptj). The modeling framework of the LMM allowed us to use the data of all participants, even when participants did not fill in the questionnaires at all follow-up measurements. As a result, data of all 701 participants were used in the analysis.

After 3 months' therapy, the mean [SD] MHQ pain score improved from 46 [17] at baseline to 58 [21], and MHQ function score improved from 66 [16] at baseline to 68 [15] (Tab. 1).

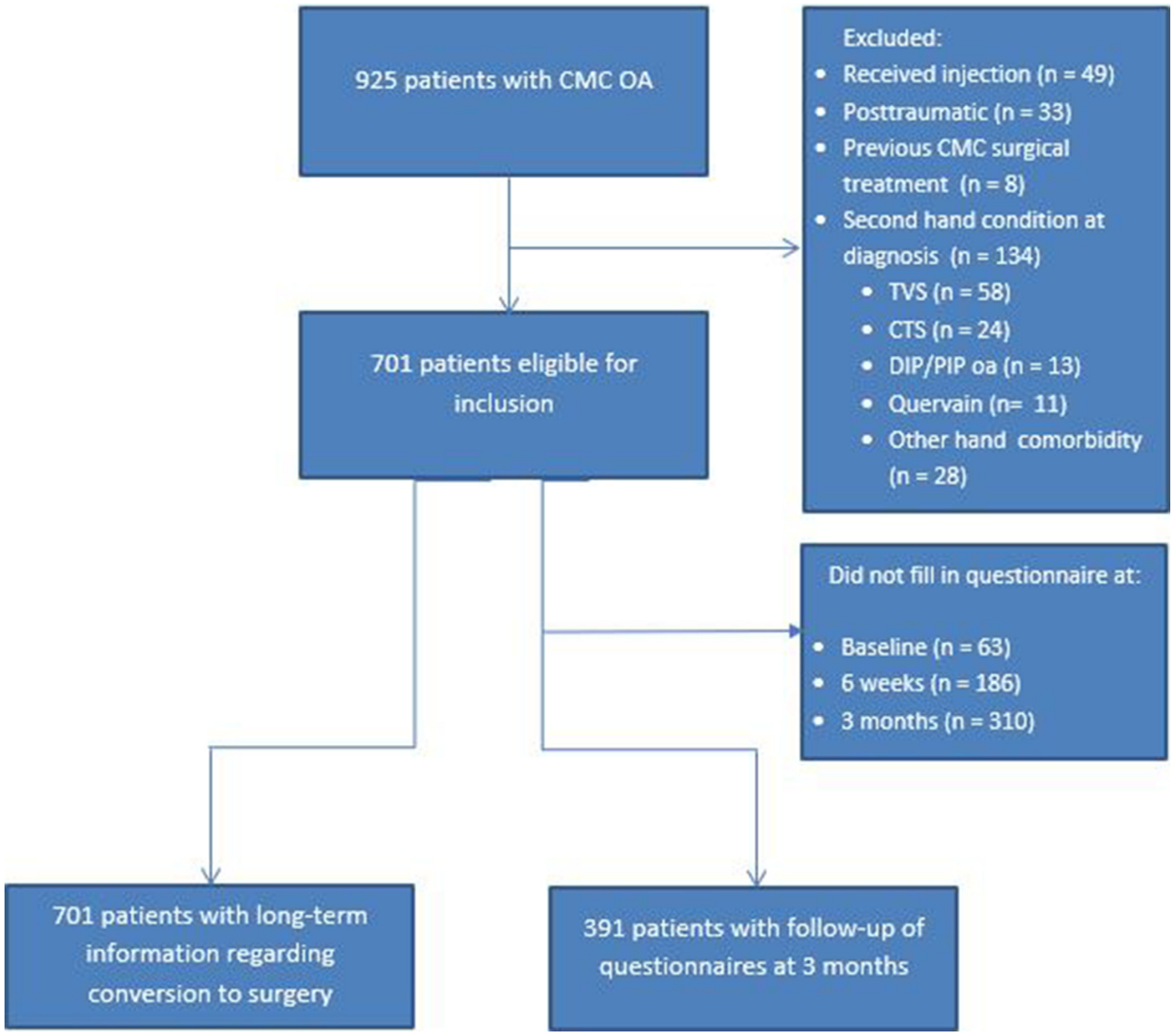

Figure.
Flowchart of study participation. Abbreviations: CMC OA = carpometarcarpal osteoarthritis; CTS = carpal tunnel syndrome; DIP/PIP oa = distal interphalangeal joint/proximal interphalangeal joint osteoarthritis; TVS = tenovaginitis stenosans.

The LMM showed that the improvement in pain between baseline and 3 months was significant ($\beta = .122 \pm .009$; $P < .001$). To interpret these numbers: For each day, the expected improvement in pain is 0.122 points. Hence, the expected score in pain at 3 months would be 62 for someone who started with a baseline pain score of 50.

Furthermore, the LMM showed that the improvement in function between baseline and 3 months was significant ($\beta = .038 \pm .009$; $P < .001$). To interpret these numbers: For each day, the expected improvement in function was 0.038. Hence, the expected score in function at 3 months would be 53 for someone who started with a baseline function score of 50.

Conversion to Surgery

In these 701 participants, after a mean follow-up period of 2.2 years, 15% underwent a surgical procedure. The constructed Cox model predicting conversion to surgery showed no significant association between the baseline participant characteristics sex, age, and side (left or right hand treated) and conversion to surgery.

The joint analytical model predicting the effect of MHQ pain score on conversion to surgery showed that both the MHQ pain at a certain point as well as change in MHQ pain score during conservative treatment were significantly associated with conversion to surgery (Tab.

Table 1.
Baseline Characteristics and Outcome After Conservative Treatment[a]

	Baseline, % or Mean [SD]	6 Weeks, Mean [SD]	3 Months, Mean [SD]
Female sex	76	NA	NA
Right hand treated	50	NA	NA
Age, y	60 [9]	NA	NA
Duration of symptoms, mo	34 [62]	NA	NA
MHQ[c]			
Function[b]	66 [16]	67 [14]	68 [15]
Pain[b]	46 [25]	54 [19]	58 [21]

[a]MHQ = Michigan Hand Questionnaire; NA = not applicable.
[b]Higher scores indicate better outcome.

2). Hence, for each 5 points higher on the MHQ pain at a certain point (ie, at baseline, 6 weeks, or 12 weeks)—for instance, a score of 65 instead of 60 at baseline—the hazard of converting to surgery decreased by 30.5%. Furthermore, for each 5-point improvement in MHQ pain at follow-up (eg, an improvement of 5 points instead of 0 points at 3 months), the hazard of converting to surgery decreased by 40.3%.

The joint analytical model between functional outcome and conversion to surgery showed only a significant association between MHQ function at a certain point, and no significant association between the change in MHQ score for function and conversion to surgery (Tab. 2). For example, for each 5 points higher on the MHQ function at a certain point (ie, a score of 65 instead of 60 at baseline), the hazard of converting to surgery decreased by 14.1%.

Internal validation showed that the area under the curve for MHQ pain was 0.738, indicating that the model has moderate to good discriminative ability. Internal validation showed that the area under the curve for MHQ function was 0.658, indicating that the model has moderate discriminative ability.

Discussion

For patients with CMC-1 OA seeking treatment, treatment guidelines recommend starting with hand therapy and an orthosis. This study investigated to what extent outcome in pain and hand function influenced the hazard of converting to surgical treatment after conservative treatment in these patients. It was found that pain levels and change in pain levels during conservative treatment significantly influenced the hazard of converting to surgical intervention. Furthermore, function levels significantly influenced the hazard of converting to surgery, whereas change in function levels was marginal and had no significant influence on conversion to surgery.

To our knowledge, only 1 other study has evaluated the percentage of patients who convert to surgery after initiating conservative treatment. Berggren et al showed a slightly higher conversion rate of 10 of 33 patients (30%) waiting for operation; these patients were treated successfully with hand therapy within 7 months before surgical intervention and, within 7 years, only 2 more patients had received additional surgical treatment.[19] However, that study did not analyze the outcome of conservative treatment and how it might be linked to conversion to surgery. In the present prospective cohort, improvement in pain during conservative treatment resulted in a lower rate of conversion to surgery.

A possible explanation for change in *function* not being related to surgical treatment is that, for these patients, the main reason for visiting an outpatient clinic is pain.[14] This is in line with the functional outcome in the present study: on a group level, only a minimal improvement in function was achieved after conservative treatment, without exceeding the minimum clinically relevant improvement of 13. Even though function levels at a certain time point influenced conversion to surgery, the effect was limited. This contrasted with the outcome for pain, where improvement after conservative treatment exceeded the minimum clinically relevant improvement of 11. In addition, pain levels at a certain time point (eg, baseline), appeared to influence the hazard of converting to surgery more than the function levels at a certain time point (eg, baseline).

Furthermore, we found that the change in pain during treatment was more important in the decision to convert to surgery than pain levels measured at a certain time point (ie, baseline) and that, of all patients, only 15% converted to surgery. Therefore, we postulate that pain is the most important motive for patients to seek care for CMC OA, and we advise always to start with conservative treatment before considering surgical intervention, even when the pain level at baseline is high.

Table 2.
Outcome of Joint Analytical Model: Relation Between Response to Therapy and Hazard of Conversion to Surgical Intervention[a]

Outcome	Variable	Hazard ratio (95% CI)	*P* value
MHQ Pain	Sex	0.79 (0.49–1.30)	.301
	Age	0.98 (0.96–1.0)	.186
	Treated hand	1.27 (0.70–1.93)	.347
	MHQ Pain at certain time	0.93 (0.92–0.94)	<.001
	MHQ Pain change at certain time	1.07 (1.06–1.09)	<.001
MHQ Function	Gender	0.95 (0.95–1.62)	.893
	Age	0.98 (0.95–1.01)	.243
	Treated hand	1.51 (1.00–2.28)	.050
	MHQ Function at certain time	0.97 (0.95–0.99)	.003
	MHQ Function change at certain time	1.0 (1.0–1.0)	.098

[a]CI = confidence interval; MHQ = Michigan Hand Questionnaire

To our knowledge, this is the first study that quantitatively supports current guidelines to start with conservative treatment before discussing the option of surgical treatment. Furthermore, based on our findings, we suggest that pain levels are monitored during conservative treatment to potentially intervene when the response to therapy suggests a higher risk of conversion to surgery. For example, hand therapists could adjust their treatment, focusing more on alleviating pain and less on improving functional outcome, or vice versa. In this way, a more individualized treatment might be provided based on the patient's response, possibly leading to better treatment outcome. In our patients, improvement in pain was achieved without a clinically relevant change in functional outcome. However, additional studies are required to further evaluate the long-term relationship between function and pain.

In cases where patients decide to convert to surgery, a good postoperative pain outcome is expected. For example, in a Cochrane review, Wajon et al compared different surgical techniques in terms of pain outcome for patients with CMC OA; on average patients had a postoperative pain score of 26 to 30 points on a 0 to 100 scale.[20]

Although our joint analytical models for conversion to surgery had moderate to good discriminative ability, there might be room for improvement, that is, other variables (eg, psychological factors) might also be important in the decision to convert to surgery. A systematic review found that depression and anxiety were highly prevalent in patients with OA, and that patients with these symptoms experienced more pain and had less optimal outcomes.[21] In addition, Becker et al[22] found that patients seeking care for CMC OA had more catastrophic thinking and higher rates of depression compared with patients who did not seek treatment for CMC OA. In the present study, however, none of these psychological factors were examined.

This study has a number of strengths and limitations. The main strength is the large sample size and its prospective nature; another strength is the high external validity, because we studied predictive factors of conversion to surgery in daily clinical practice.

A limitation is the lack of a control group receiving no conservative treatment. This implies that it is unknown whether the change in pain level during conservative treatment was caused by the conservative treatment or by other unrelated factors, such as regression to the mean or spontaneous improvement. Moreover, the multicenter, multisurgeon design of our study might have caused clustering by these factors, resulting in standard errors that could have been too small. Due to the already complex joint models, we decided not to add another factor (ie, location, surgeon) to our analysis in order to reduce complexity. Another limitation is the substantial amount of missing data, which might have resulted in biased estimates. However, based on responder/nonresponder analysis, we can justify that data missing at 3 months were missing at random, meaning that the hazard of the missing values was dependent on the observed data, but independent of the unobserved data. Using the maximum likelihood approach of our LMM allowed us to take this into consideration, thereby reducing bias.

In conclusion, this study found that pain, function, and change in self-reported pain level of the treated hand during treatment was associated with the probability of conversion to surgical intervention, whereas change in self-reported function had no significant influence on

conversion. Therefore, we suggest that structured monitoring of self-reported pain during and after conservative treatment might help to prevent patients from converting to surgery.

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Ethics Approval

The study was approved by the local institutional review board and written informed consent was obtained from all patients.

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Disclosure

The authors completed the ICJME Form for Disclosure of Potential Conflicts of Interest and reported no conflicts of interest.

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