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A Prospective Outcomes Study of Swanson Metacarpophalangeal Joint Arthroplasty for the Rheumatoid Hand

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Abstract

Purpose: Destruction and dislocation of the metacarpophalangeal (MCP) joints are common occurrences in patients with rheumatoid arthritis (RA). Disruption of the support ligaments around the MCP joints and ulnar deviation of the fingers affect hand function and hamper the ability to perform activities of daily living. A common surgical intervention is the Swanson Metacarpophalangeal Joint Arthroplasty (SMPA), which restores alignment of the fingers.

Methods: We conducted a prospective study with 16 patients to determine outcomes of this procedure. We present our data from the 6-month and 1-year follow-up periods.

Results: Functional assessment by grip strength, pinch strength, and Jebsen-Taylor Test did not improve significantly when compared with preoperative values. Subjective assessment by the Michigan Hand Outcomes Questionnaire (MHQ), however, did improve significantly. Large improvements were seen in the function, activities of daily living, aesthetics, and patient satisfaction domains, with preoperative to 1-year postoperative score improvements of 26, 42, 57, and 43 points, respectively, based on a 100-point scale. Ulnar drift significantly decreased 1 year after surgery by an average of 24° and MCP joint range of motion increased, but this change was not significant.

Conclusions: Our data show that patients with RA who underwent SMPA had significant improvements in patient-reported outcomes at the 1-year interval. Continued follow-up evaluation of this cohort will determine whether these improvements are maintained in the long term.

Keywords

Arthroplasty; metacarpophalangeal joint; outcomes; rheumatoid arthritis; Michigan Hand Outcomes Questionnaire

Approximately 31 million people in the United States report that they have some type of arthritis, with rheumatoid arthritis (RA) being the second most common type.¹ A prevalence study reported by the National Arthritis Data Workgroup estimates that 1% of adults in the United States have RA, which translates to 2.1 million people, 1.5 million of them women.²

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A common hand deformity in RA results from the destruction of the metacarpophalangeal (MCP) joints with dislocation of these joints and ulnar deviation of the fingers.

Silicone implants have been used since the late 1960s to replace destroyed MCP joints in the rheumatoid hand. The Swanson silicone implant (Dow Corning, Midland, MI) has emerged as the preferred choice because of its flexibility and durability.³ We chose to use the Swanson implant in this study because it is the most commonly used implant, having 75% of the US market for implants in the rheumatoid hand (personal communication, Wright Medical Technology, Arlington, TN). Despite the long-term use of Swanson implants, most published reports consist of uncontrolled retrospective case series that were based mainly on physical outcomes such as finger range of motion, grip strength, and degrees of residual ulnar drift.^{3, 4–24} Although these physical measures are important in assessing the biomechanical changes in the rheumatoid hand, other outcome parameters such as the ability to work and to perform activities of daily living may be more meaningful to patients and third-party payers. This is a prospective outcomes study to evaluate the effectiveness of the Swanson Metacarpophalangeal Joint Arthroplasty (SMPA) by using standardized hand function tests and validated hand- and RA-specific questionnaires.

Controversy exists between hand surgeons and rheumatologists about the effectiveness of arthroplasty in improving hand function for RA patients with MCP joint disease. In our national survey of hand surgeons and rheumatologists, 83% of hand surgeons versus 34% of rheumatologists felt that MCP arthroplasty always or usually improves hand function ($p < .0001$).²⁴ One of the main reasons for the disagreement between the 2 specialties is that in general rheumatologists feel that outcome data on SMPA are inadequate to support its continued use.

The purpose of this study was to provide short-term (6 month and 1 year) objective and subjective quantitative data on the effectiveness of the MCP arthroplasty procedure for use in patient counseling and for physician reference. The intent of this study was not to evaluate the Swanson implant per se, but to measure the effectiveness of the implant arthroplasty procedure at the MCP joint position. This study is part of a larger, multicenter, prospective cohort study sponsored by the National Institute for Arthritis and Musculoskeletal and Skin Diseases (R01 AR47328) to evaluate outcomes of MCP arthroplasty when compared with a medically treated control group.

Materials and Methods

Patient Enrollment

Patients were enrolled consecutively when they attended the University of Michigan Plastic Surgery Hand Clinic for an assessment. All aspects of the study were approved by the University of Michigan Institutional Review Board and written informed consent was obtained. The surgery was performed by a single surgeon (K.C.C.), also the principal investigator of this study. An *a priori* sample size calculation was not performed because we did not have outcomes data to determine the effectiveness of this procedure. Enrollment criteria included a diagnosis of RA, stage 3 or stage 4 MCP joint disease, the need for arthroplasty on all 4 MCP joints with and without thumb MCP fusion, age greater than 18 years, and an ability to read and understand English (to complete the study questionnaires).

Metacarpophalangeal joint disease can be classified into 4 stages— early, moderate, late, and very late.²⁵ Stage 3 (late) disease is characterized by definitive erosion of the articular cartilage by radiographs. Patients with stage 3 disease usually complain of pain at the MCP joints and have an extensor lag of at least 20° and ulnar deviation of 15° to 20°. By stage 4 (very late) there is a great deal of joint destruction on radiographs and fixed volar subluxation of the

proximal phalanx. Because of the fixed flexion deformity (extensor lag of $\geq 30^\circ$) and reduced flexion arc, stage 4 patients experience difficulty opening their hands to hold large objects. Furthermore their fingers have greater than 25° of ulnar deviation, which hinders their prehension and hand dexterity.

Functional Assessment

At study enrollment patients were asked to undergo a hand function assessment by a certified hand therapist assigned to this project. This assessment consisted of the measurement of grip strength, lateral, tip, and palmar pinch strength, finger range of motion, ulnar deviation, and the Jebsen-Taylor test. The Jebsen-Taylor test simulates activities of daily living and consists of 7 components: (1) writing a short sentence, (2) turning over 3- by 5-inch cards, (3) picking up small objects and placing them in a container, (4) stacking checkers, (5) simulated eating, (6) moving large empty cans, and (7) moving large weighted cans.²⁶ For each component, the time required in seconds to complete the task is recorded for the patients' dominant and nondominant hands. In the population with RA the Jebsen-Taylor test was shown to be particularly useful in discriminating different levels of rheumatoid hand impairment.²⁷ Because writing is highly dependent on hand dominance, prior studies have reported difficulty in interpreting the results of the writing component of the Jebsen-Taylor test.^{26,27} For this reason we excluded the writing component from our data collection. For one study patient who was unable to pick up the empty or weighted cans before surgery we estimated these tasks to be 20 seconds each, which was twice as long as the slowest patient completing these tasks.

Study Questionnaires

Patients were asked to complete the Michigan Hand Outcomes Questionnaire (MHQ)^{28,29} before surgery. The MHQ is a hand-specific outcomes questionnaire that contains 6 domains: overall hand function, activities of daily living, pain, work performance, aesthetics, and patient satisfaction. Patients also were asked to complete the Arthritis Impact Measurement Scales (AIMS2) questionnaire,³⁰ a health status questionnaire specifically designed to measure health status in arthritis patients. It contains 12 scales that are categorized into 4 domains: physical, affect, symptom, and social interaction.

Postoperative Assessment

Approximately 6 months after surgery and a year after surgery patients returned to the clinic for postoperative assessments. At these follow-up evaluations an identical hand function assessment was conducted and patients again were asked to complete the MHQ and the AIMS2 questionnaire. In the larger prospective study, SMPA patients will be followed up at 6 months, 1 year, 2 years, and 3 years after surgery. Clinic appointments were scheduled for patients at the designated follow-up periods. For patients who canceled their follow-up appointment we attempted to contact them by phone and request that they reschedule their appointment. For patients who could not be contacted by phone or were unable or unwilling to return for an appointment we sent a letter asking them to reschedule their appointment. Follow-up questionnaires were included with the letter and the patient was asked to complete them even if he or she could not return to the clinic for the functional assessment.

Data Analysis

As a primary measure of the effectiveness of SMPA, mean change scores from baseline to after SMPA of each of the objective outcome measures or subscales of the questionnaires were calculated and the mean change scores were compared with 0 using paired *t* tests. Additionally, the standardized effect size was used to report and assess the magnitude of change. The effect size was defined as $(\text{mean1} - \text{mean2}) \div (\text{SD of difference in means})$. Cohen³¹ considered the effect size of 0.2 to be small, 0.5 to be medium, and 0.8 to be large.

Because the data were collected at 3 time points, in addition to the paired t tests, longitudinal trends also were explored. The trend was explored first by using graphic tools by plotting the mean and 95% confidence intervals of the outcome scores or subscale scores over time at 3 time points. Because such cross-sectional mean plots do not necessarily reflect the underlying individual patterns we also graphed the data over time individually. Further data analyses were guided by examinations of these plots, followed by fitting a statistical model that accounts for within-person correlation from having multiple observations per patient. Statistical modeling for longitudinal data was performed using random-effect models with the outcome scores at 3 time points as the dependent variable.³² The model allowed for flexible modeling of the functional relationship between the outcome measure and time, while accounting for the within-person correlation and adjusting for baseline differences by including the baseline values of the outcome variable. As an example of the analysis, if the graph showed increasing outcome status from baseline to 6 months after SMPA, which remained the same at 1 year after SMPA, then a model appropriate for the combined post-SMPA effect was used. In this case the primary independent variable was the indicator for posttreatment times (6 mo and 1 y). If the treatment effect appeared different between 6 months and 1 year then 2 separate indicators, one each for 6 months and 1 year, were included to assess the separate treatment effects for the 2 posttreatment times. If the treatment effect appeared to be increasing continuously, then time was included as a continuous variable to model the trend over time.

Whenever no change was seen over time the p value from the paired t test was used. When a change over time was seen both from the graphs and the paired t test, however, the p value from the more sophisticated model was reported to reflect the specific effect over time, such as an increasing trend. Statistical significance was set at .05 or less. For each questionnaire, whenever subscales (domains) were the outcomes of interest, statistical significance level was adjusted for multiple comparisons using the Bonferroni method. For example, in the MHQ, because there were 6 domains, the statistical significance was set at .008 (.05/6) rather than at .050 to protect the overall type I error level at .05. Thus the p value of each domain must be less than .008 to be statistically significant.³³ Statistical analysis software (SAS version 8.00; Cary, NC) was used to analyze the data.

Results

As of June 2003, 16 patients have enrolled in the study. Data for the 16 patients—14 women and 2 men—are shown in Tables 1–4. The mean age at enrollment was 57 years (range, 29–88 y).

As shown in Table 1 there were no significant changes 6 months or 1 year after surgery in any of the functional tests when compared with preoperative values. All of the pinch strength tests increased 1 year after surgery, but grip strength slightly decreased. The Jebsen-Taylor test improved 1 year after surgery by 5 seconds, which was not statistically significant but indicates a modest improvement. There was no significant trend over time for any of the functional measurements.

Table 2 shows that all but one of the MHQ domains significantly improved after surgery at 1 year. The smallest change was in the work domain, which increased over time but not significantly ($p = .10$). All other domains significantly improved over time (all $p < .01$). A mean score of 80 for the activities of daily living domain after SMPA indicates that these patients are able to function better than patients with carpal tunnel syndrome (mean score = 70) and almost as well as the same patients after carpal tunnel release (mean score = 88).³⁴ After SMPA surgery the patients were better able to perform tasks with their hands. In addition they have less pain and better hand appearance and are satisfied with their overall outcome. When random-effect models were fit to model the effect of time on each of the domains, all but the

work domain showed their scores to increase over time, and the trend was statistically significant after Bonferroni correction. Figure 1 shows the mean overall MHQ scores and SDs plotted over time.

The data in Table 3 indicate that there was a significant improvement 1 year after surgery in ulnar drift. Ulnar drift decreased by 24° after the SMPA procedure ($p < .01$). The average MCP joint range of motion for all fingers improved by 13° but this improvement was not significant ($p = .99$). The arc of motion in this study favors extension, which also has been shown in a prior series. Figure 2 shows the mean results and SDs of ulnar drift plotted over time and Figure 3 shows the mean MCP joint range of motion measurements and SDs plotted over time.

Table 4 shows that all domains of the AIMS2 questionnaire decreased 1 year after surgery, indicating an improved health status, but these decreases were not statistically significant. Because RA is a systemic condition, patients are not likely to perceive that their overall health status is greatly improved with the improvement of hand function only.

Discussion

Rheumatoid arthritis is a crippling disease that severely affects the quality of life for millions of Americans; this disease is responsible for more than 250,000 hospitalizations and over 9 million physician visits each year.³⁵ Because RA is a progressive joint disease that adversely affects patients' function it is estimated that 60% of RA patients who have had the disease for over 10 years are on work disability.³⁶

Because the hand often is damaged by RA, effective surgical treatment of hand deformities can improve patient function and restore independence. A common type of debilitating hand deformity in the rheumatoid hand is ulnar deviation and volar subluxation of the fingers at the MCP joints. This type of deformity prevents RA patients from opening their hands to hold objects or to pick up utensils for eating, resulting in a considerable handicap. In addition the erosion of the cartilage in the MCP joints causes chronic pain, which further hinders hand performance. It is estimated that when the disease has persisted for more than 5 years, 45% of RA patients will present with ulnar drift deformity.³⁷

Surgical management of hand conditions in the RA population is controversial. Our previous study showed significant variation in procedure rates for arthrodesis, arthroplasty, and tenosynovectomy across the 19 states represented in the Healthcare Cost and Utilization Project Nationwide Inpatient Sample ($p < .0001$).^{38,39} This large area variation appears to be physician-driven. Our recent national survey on attitudes of hand surgeons and rheumatologists showed a significant difference in opinion regarding many procedures for the RA hand, including MCP arthroplasty.²⁴ Comparing surgeons with rheumatologists regarding the effectiveness of MCP joint arthroplasty, 83% versus 34% believe it improves hand function ($p < .0001$), 92% versus 59% believe it decreases pain ($p < .0001$), and 95% versus 67% believe it improves hand aesthetics ($p < .0001$). Rheumatologists in particular felt that the quality of literature on RA hand procedures was inadequate. Our systematic review of the SMPA literature supported this concern because we found most of the published series were retrospective without adequate methodologic rigor.⁴ The main purpose of this project was to collect a prospective series of patients with comprehensive preoperative and postoperative functional and questionnaire evaluations of this procedure. The advantage of a prospective cohort study is that outcomes measures are determined *a priori* and patients were evaluated at specific time intervals. Data points were collected uniformly in this cohort with identical surgical protocols.

We found that although the objective measurements such as grip and pinch strength did not dramatically improve in the short term after SMPA, the subjective assessment, as measured

by the MHQ, improved dramatically. These data provide support for the importance of using hand-specific, health-related, quality-of-life questionnaires to assess the outcomes of hand surgical procedures. As highlighted in a *Journal of Hand Surgery* editorial,⁴⁰ hand surgeons often stress functional measures rather than aesthetics when measuring postoperative improvement. Patients, however, often are as concerned with how an extremity looks as they are with how it functions. The aesthetics domain in the MHQ increased 57 points from the preoperative mean to the 1-year postoperative mean. Patients were very satisfied with the results of SMPA. The degree of ulnar drift significantly decreased after surgery, improving both function and appearance. The range of motion at the MCP joints did not notably improve but the arc of motion favors the extension arc. The extension arc places the fingers in a more biomechanically advantageous posture. Hand strength did not notably increase after surgery. These objective findings are consistent with those found in our systematic review. Although the rheumatoid hand is weakened by the disease with inflammation and atrophy of the interosseous and extrinsic muscles, by correcting the MCP deformity, SMPA greatly improved patients' ability to perform daily activities, which may decrease their dependence on ancillary help.

A recently published retrospective study⁴¹ indicated that MCP joint arthroplasty in RA patients worsens with long-term follow-up evaluation. Data were analyzed for 36 patients with postoperative duration ranging from 6 to 21 years. These investigators found that 67% of Swanson implants were broken, and average ulnar drift was 10° for digits with an intact implant and 20° for digits with a fractured implant. We are aware that our study patients may show similar implant deterioration over time. Because RA is a chronic systemic disease, no surgical procedure will be long lasting because of the constant insults of this autoimmune disorder. Our results, however, show great improvement in the short term at 6-month and 1-year follow-up periods. Physicians should inform patients that surgical results may not be maintained in the long term but patients should be given the choice as to whether the large improvements seen in the short term justify undergoing this procedure. Patients in our prospective study will continue to be evaluated at yearly intervals with objective and subjective assessments to determine whether continued improvement is observed.

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Figure 1.

MHQ overall mean scores improve dramatically 6 months after surgery and are maintained at the 1-year follow-up evaluation.

Figure 2.

Ulnar drift significantly decreased 6 months after surgery and improved results are maintained at the 1-year follow-up evaluation.

Figure 3. MCP joint range of motion shows improvement over time, however, these improvements are not statistically significant.

Table 1

Preoperative and Postoperative Functional Scores

Test	Preoperative Mean ± SD	6-Month Postoperative Mean ± SD	1-Year Postoperative Mean ± SD	p Value [*]
Grip strength (kg)	5.9 ± 4.6	5.0 ± 3.2	6.2 ± 2.7	.51
Key (lateral) pinch (kg)	5.5 ± 3.4	5.7 ± 3.1	6.5 ± 2.4	.24
2-point (tip) pinch (kg)	3.3 ± 2.8	3.2 ± 2.2	3.9 ± 1.8	.17
Three jaw (palmar) pinch (kg)	3.8 ± 3.2	4.6 ± 3.0	5.0 ± 2.6	.15
Jebsen-Taylor (s)	44.8 ± 13.8	38.5 ± 9.2	39.9 ± 11.4	.73

* The p values were calculated as paired *t* tests comparing preoperative mean and 1-year postoperative mean. No trend over time was detected.

Table 2

Preoperative and Postoperative MHQ Scores

MHQ Scale	Preoperative Mean $\pm$ SD	6-Month Postoperative Mean $\pm$ SD	1-Year Postoperative Mean $\pm$ SD	p Value [*]	Effect Size [‡]
Function	40.0 $\pm$ 17.1	68.5 $\pm$ 21.2	65.8 $\pm$ 18.8	<.01 [†]	1.3
Activities of daily living	38.0 $\pm$ 26.3	66.4 $\pm$ 15.9	80.3 $\pm$ 13.4	<.01 [†]	1.2
Work	31.3 $\pm$ 31.0	53.5 $\pm$ 31.1	44.2 $\pm$ 13.9	.10	0.3
Pain	65.0 $\pm$ 18.8	42.0 $\pm$ 18.7	40.8 $\pm$ 13.9	<.01 [†]	1.3
Aesthetics	30.0 $\pm$ 21.9	68.1 $\pm$ 31.7	86.5 $\pm$ 19.1	<.01 [†]	3.0
Satisfaction	15.6 $\pm$ 11.3	72.1 $\pm$ 22.7	59.0 $\pm$ 20.0	<.01 [†]	1.8
Overall score	31.6 $\pm$ 14.3	64.4 $\pm$ 16.4	65.8 $\pm$ 9.1	<.01 [†]	2.2

All of the MHQ scales are based on a scale of 0 to 100. For all of the scales except pain, the higher the scores, the better the subject's hand performance. For the pain scale, the lower the score, the less pain the subject experienced.

^{*} The p values were calculated from a random-effect model, assessing trend over time.

[†] Statistically significant after Bonferroni correction.

[‡] For paired data the effect size is defined as (mean1 – mean2) ÷ (SD of difference in means).³¹ For example, for function, effect size = (65.8 – 40.0) ÷ (19.8). Effect size of 0.2 is small, 0.5 is medium, and 0.8 is large.³¹

Table 3
Preoperative and Postoperative Range of Motion Scores

Test	Preoperative Mean $\pm$ SD	6-Month Postoperative Mean $\pm$ SD	1-Year Postoperative Mean $\pm$ SD	p Value *
Ulnar drift	33.6 $\pm$ 15.2	8.4 $\pm$ 4.6	9.4 $\pm$ 5.7	<.01
MCP joint range of motion	33.0 $\pm$ 20.8	40.3 $\pm$ 10.7	46.0 $\pm$ 5.9	.99

* The p values were calculated using paired *t* tests comparing preoperative mean and 1-year postoperative mean.

No trend over time was detected.

Table 4

Preoperative and Postoperative AIMS2 Scores

AIMS2 Scale	Preoperative Mean $\pm$ SD	6-Month Postoperative Mean $\pm$ SD	1-Year Postoperative Mean $\pm$ SD	p Value	Effect Size
Physical	3.5 $\pm$ 2.1	2.5 $\pm$ 1.8	1.6 $\pm$ 1.0	.49	0.5
Affect	3.5 $\pm$ 1.9	2.7 $\pm$ 1.2	2.5 $\pm$ 0.8	.29	0.4
Symptom	6.2 $\pm$ 2.1	5.2 $\pm$ 1.9	5.4 $\pm$ 2.0	.81	0.1
Social interaction	3.6 $\pm$ 1.3	4.2 $\pm$ 1.4	3.2 $\pm$ 1.3	.96	0.2

All of the AIMS2 scales are based on a scale of 1 to 10. For all of the scales, the lower the scores, the better the subject's health status.

* The p values were from a random-effect model, assessing trend over time.