Reconstructing the Rheumatoid Wrist: A Utility Analysis Comparing Total Wrist Fusion and Total Wrist Arthroplasty from the Perspectives of Rheumatologists and Hand Surgeons

Christi M. Cavaliere · Adam J. Oppenheimer · Kevin C. Chung

Received: 20 February 2009 / Accepted: 26 March 2009 / Published online: 28 April 2009
© American Association for Hand Surgery 2009

Abstract Rheumatologists and hand surgeons have historically demonstrated strikingly divergent attitudes toward the benefits of surgical intervention, either total wrist fusion or total wrist arthroplasty, for the rheumatoid wrist. A utility analysis was conducted to compare a national random sample of hand surgeons and rheumatologists regarding their opinions about surgical management of severe rheumatoid wrist disease. A web-based trade-off utility survey was developed, and participants were presented with survey scenarios comparing well-controlled rheumatoid arthritis with operative and non-operative management. Utility values were calculated for each scenario, and a decision analytic model was constructed. Utility values for rheumatologists and hand surgeons did not differ significantly for any scenario. Total wrist arthroplasty was associated with the highest expected gain in quality-adjusted life-years for

each subgroup. This decision analytic model demonstrates similar opinions between two subspecialties that have historically demonstrated divergent attitudes towards rheumatoid hand surgery.

Keywords Utilities · Physician perspectives · Wrist fusion · Wrist arthroplasty

Rheumatoid arthritis (RA) is a chronic illness with substantial morbidity. An estimated 1% of the US population is affected with RA [13]. Much of the morbidity from this disease can be attributed to hand dysfunction [3], and more than 70% of RA patients have some form of hand impairment [7]. The wrist is often the first joint to be affected in the upper extremity, and typically, the distal radioulnar joint shows destruction in early phases of this disease. Long-term follow-up studies demonstrate that over 90% of RA wrists become symptomatic. Because the primary care physicians for these patients are typically rheumatologists, it is crucial that these specialists have a comprehensive understanding of medical and surgical management of rheumatoid wrist disease.

Given the debilitating nature of RA, improving health-related quality of life is a major concern. Total joint arthroplasty procedures have gained widespread acceptance with total knee and hip replacements. These procedures have enjoyed over a century of refinement in the quest for a better prosthesis [11]. Hand surgeons have also been working toward this goal. Total wrist arthroplasty was first popularized in the late 1960s with the use of a flexible silicone implant [19]. These first generation prostheses were later replaced by more robust metal components [14, 21]. Due to joint imbalance with earlier metal implants, newer total wrist prostheses attempt to optimize the center

C. M. Cavaliere
Section of Plastic Surgery, Department of Surgery,
University of Michigan and VA Ann Arbor Health System,
Robert Wood Johnson Clinical Scholar,
Ann Arbor, MI, USA

A. J. Oppenheimer
Section of Plastic Surgery, Department of Surgery,
University of Michigan,
Ann Arbor, MI, USA

K. C. Chung
Section of Plastic Surgery, Department of Surgery,
University of Michigan,
Ann Arbor, MI, USA

K. C. Chung (✉)
University of Michigan Health System,
2130 Taubman Center, SPC 5340, 1500 E. Medical Center Drive,
Ann Arbor, MI 48109-5340, USA
e-mail: kecchung@umich.edu

of wrist motion and emphasize more modest bone resection. Newer devices are better than their predecessors but continue to have high revision and failure rates compared to other large joint arthroplasties [9].

Despite over 40 years of dedicated efforts, no prospective, randomized controlled trial has been performed to compare outcomes of total wrist fusion (TWF) and total wrist arthroplasty (TWA) for RA patients. In the absence of clear evidence of a superior outcome, a decision analytic model becomes a valuable tool for comparing treatment options [8]. A precise value is assigned to each surgical intervention, taking into consideration an individual's preferences for the potential outcomes and complications. Utility defines the individual's preference for a given treatment option or health state. By convention, a value of 1.0 is equivalent to perfect health whereas a value of 0 is equivalent to death [10]. Preferences can be converted from utility values to quality-adjusted life-years (QALYs) based on the time spent in the given health state. QALYs are compared across treatment options to evaluate the overall expected benefit for the patient, including effects on both quality and quantity of life.

The aim of this study is to evaluate and quantify the utility that rheumatologists and hand surgeons assign to TWA and TWF for the severely diseased rheumatoid wrist. In the absence of rigorous outcome data to guide the decision-making process, selection of a treatment option relies on the beliefs and preferences of the counseling rheumatologists and hand surgeons. This decision analytic model will allow us to assess physician preferences in the form of utilities and will help us to understand the factors that contribute to the decision-making process. In addition, physician-rated utility may provide insight into potential reasons why TWA has failed to gain widespread application in the RA wrist.

Patients and Methods

Study Sample

A cohort of 125 rheumatologists was randomly selected based on 2007 membership in the American College of Rheumatology. Members were numbered in alphabetical order, and a random number generator was used for selection. After exclusion of international, pediatric, and emeritus physicians, we were able to establish contact with 119 rheumatologists. Similarly, a random sample of 175 hand surgeons was selected based on 2007 membership in the American Society for Surgery of the Hand (ASSH). International and emeritus members were excluded. After excluding recruitment letters that were returned due to incorrect address, a total of 164 surgeons were contacted to

complete the survey. Subjects were assigned a login number, and individual responses to the survey remained anonymous.

Survey Design

The study protocol was approved by the Institutional Review Board at the University of Michigan. A web-based survey was constructed using an online survey engine. The survey was designed for completion within approximately 20 min and included ten-time trade-off (TTO) scenarios (Appendix) followed by a demographic questionnaire. The TTO model was chosen because it represents a direct measure of utility that is not based on inference [20]. Physicians were asked to answer questions based on the TTO model, choosing between a surgical intervention or well-controlled RA. In this fashion, subjects were asked to “trade-off” years of life in exchange for the more favorable health state. When the options were considered equal, the physician was able to select “It's too hard to choose,” which defined the so-called point of indifference. At the point of indifference, the utility of the intervention described in the scenario is equal to x/t , in which x equals the number of years in the more desirable health state (a painless, well-functioning wrist), and t equals the number of years in the alternative health state (TWF, TWA, or non-operative management). For example, the first scenario presents a choice between living for 30 years with a painful, poorly functioning RA wrist and living for 30 years with a painless, well-functioning wrist. The logical choice is the well-functioning wrist option. Although it may seem unnecessary to present scenarios that would elicit such predictable responses, this scenario allows the respondent to familiarize him/herself with the survey format and is a standard protocol for utility surveys. After the first selection, the time options change. The subject is then asked to choose between living for 30 years with a poorly functioning RA wrist and living for 15 years with a painless, well-functioning wrist. In each iteration of a given scenario, the number of years with a painless, well-functioning wrist decreases until the subject reaches the point of indifference, when the two options are considered to be equal. If the subject above has equated 15 years with a painless, well-functioning wrist to 30 years with a painful RA wrist, the subject's utility for the RA wrist is $15/30$ or 0.5. Similarly, if the subject feels that 10 years with a painless, well-functioning wrist is equal to 30 years with a painful RA wrist, then the subject's utility for the RA wrist is $10/30$ or 0.33.

Data Analysis

Data were evaluated using STATA (STATA v10, STATA Corp., College Station, TX, USA) and SAS (SAS v9.1,

SAS, Cary, NC, USA). Mean values for utility, with 95% confidence intervals (CI), were calculated for both subgroups in each scenario. Comparisons between the two subgroups were made using the Student's *t* test. A decision tree was created using the TreeAge software program (TreeAge Pro Excel, Version 2008; TreeAge Software, Inc., Williamstown, MA, USA). Initial branches of the tree include the three possible management options for severe RA wrist disease: non-operative management, TWA, and TWF (Fig. 1). Three assumptions of this model must be noted: Each patient may have only one complication, each complication has a definitive outcome, and a successful prosthesis lasts for the duration of the patient's life. For the two operative interventions, subsequent branches show all potential outcomes of surgery, including no complication, minor complication, intermediate complication and major complication. Complication rates for each of these possibilities were derived from a systematic review of the literature [6]. Additional required values include the anticipated years of healthy life remaining and the duration of the health state under investigation. For example, recovery from a TWA complicated by delayed wound healing would take approximately 1 month (0.083 years). The equation used for calculation of expected QALYs for each possible treatment and complication is shown in Fig. 2. The baseline years of remaining life used for QALY calculations was 30 years.

Values used to calculate QALYs can vary. Complication rates are inexact and healthy remaining years of life are difficult to predict. The TreeAge program allows a sensitivity analysis to vary the assumptions of the model and convey associated changes in outcome. For example, varying complication rates across lower and higher rates reported in the literature allows us to evaluate how the

expected QALYs would concordantly change. Similarly, a person with 12 remaining years of life would have a different expected gain in QALYs after a procedure than a person with 20 remaining years of life. Sensitivity analysis is therefore necessary to evaluate the robustness of a decision model [17]. A model in which the same procedure is associated with the largest expected gain in QALYs regardless of changes in model parameters is considered to be robust.

Results

Survey Response Rate

A total of 36 rheumatologists (30%) and 73 hand surgeons (45%) completed the entire survey. The difference in response rates between the two cohorts was statistically significant by two-tailed Fisher's exact test (p value = 0.019). The most critical consideration in any survey with non-response is whether the opinions obtained from the survey sample represent the opinions of the population or if a self-selection bias has occurred. Because of the prohibitive cost associated with surveying the entire population, which would be over 2,000 members of the ASSH and over 5,000 members of the American College of Rheumatology, we performed a survey using a simple random sampling without replacement sampling scheme in order to provide inference of the opinions of the overall population. If there is a self-selection bias, it would not be solved by sending surveys to all the hand surgeons and all the rheumatologists in the USA because the individuals who choose to participate would still be non-representative of their subspecialty. We hypothesize that the lower response rate for rheumatologists is due to their relative unfamiliarity with

Figure 1 Severe RA wrist disease. The decision tree shows the survey options and associated QALYs assigned by rheumatologists and hand surgeons. This is a typical decision tree in which the probability of each scenario is multiplied by the assigned utility to generate the QALYs for each scenario. All the QALYs are added to generate a total QALY score that will be used to compare among the three decision choices to the left of the tree to arrive at a dominant treatment choice.

Figure 2 Equation used for calculation of QALYs.

$$(\text{Duration of Health State}) \times (\text{Utility Health State}) + (\text{Healthy Years} - \text{Complication Time}) \times (\text{Utility Healthy Years}) = \text{QALYs}$$

Sample Calculation: TWF with Intermediate Complication (symptomatic hardware requiring removal)

Health State = Complication (symptomatic hardware)

Duration of Health State = 4 weeks (0.077 years)

Utility Complication (from rheumatologist survey scenario) = 0.79

Healthy Years = 30

Utility Remaining Healthy Years = utility patient will have after complication resolves*
= 0.75

*Same as utility for uncomplicated TWF (from survey scenario)

$$(0.077 \text{ years}) \times (0.79) + (30 \text{ years} - 0.077 \text{ years}) \times (0.75) = 22.5 \text{ QALYs}$$

the current state of wrist procedures for patients with RA. Because wrist arthroplasty is a new advancement for the treatment of destructive rheumatoid wrist diseases, many rheumatologists referring patients for surgical consultation may not be aware that TWA is an available alternative to TWF. Rheumatologists may therefore have little interest in survey participation or may feel uncomfortable assigning utilities for these two treatments.

Demographic Data

Demographic data for the physician subgroups are shown in Table 1. Respondents tended to be very experienced practitioners. All responding physicians had been in practice for at least 5 years. Based on the demographic

profile of the responding physicians, RA patients with severe wrist involvement would certainly undergo counseling by both rheumatologists and hand surgeons with clinical practices and experience similar to these physicians.

Utility Survey

Utility values for each scenario are presented in Table 2. Minimal difference in mean utility is noted between rheumatologist and hand surgeon subgroups. None of these differences is statistically significant ($p > 0.05$) and the 95% CI overlap for all values. Non-operative management (Scenario 1) was associated with lower utility than operative intervention in each subgroup. We performed a post hoc sample size calculation based on sample data: with

Table 1 Demographic Data

Group	Years In Practice	Setting	% Practice Dedicated to Hand	% Practice Dedicated to RA
Rheumatologists	21 (6 to >30)	Academic 39% Private 50% Combination 11%	N/A	Mean = 88%* (10% to 100%)
Hand Surgeons	19 (5 to >30)	Academic 26% Private 55% Combination 19%	Mean = 83%** (5% to 100%)	N/A

*81% of responding rheumatologists reported at least 90% of their practice is dedicated to rheumatologic diseases

** 67% of responding hand surgeons reported at least 90% of their practice is dedicated to hand surgery

Table 2 Mean utility values (95% CI) for rheumatologists and hand surgeons

Scenario	Surgeons	Rheumatologists	p-value**
1	0.54 (0.46 – 0.61)	0.58 (0.48 – 0.68)	0.53
2	0.82 (0.75 – 0.88)	0.75 (0.66 – 0.84)	0.18
3	0.85 (0.79 – 0.90)	0.78 (0.69 – 0.86)	0.12
4	0.86 (0.81 – 0.92)	0.79 (0.70 – 0.88)	0.08
5	0.82 (0.76 – 0.88)	0.79 (0.70 – 0.87)	0.44
6	0.85 (0.79 – 0.91)	0.84 (0.76 – 0.92)	0.62
7	0.85 (0.78 – 0.91)	0.88 (0.81 – 0.95)	0.91
8	0.86 (0.80 – 0.92)	0.88 (0.81 – 0.96)	0.82
9	0.82 (0.76 – 0.88)	0.81 (0.73 – 0.89)	0.79
10	0.82 (0.76 – 0.88)	0.79 (0.71 – 0.88)	0.39

*Based on an unpaired t-test between the two physician subgroups

36 rheumatologists and 73 hand surgeons responding, we can detect a difference of 0.18 in population mean utility score with 80% power and assuming p values of 0.05 or less are significant. No distinct decrease in utility was seen with worsening complications.

An established referral relationship with a hand surgeon did not affect rheumatologists' utility values for uncomplicated TWF. Rheumatologists reporting a referral relationship with a hand surgeon had a utility of 0.79 for uncomplicated TWF compared to 0.63 for rheumatologists without a hand surgery referral relationship ($p=0.13$). Similarly, utility for uncomplicated TWA showed no statistically significant difference among rheumatologists with a hand surgery referral relationship (0.85) compared to rheumatologists without a referral relationship (0.80, $p=0.59$).

Decision Analytic Model

Utility values obtained from rheumatologist and surgeon surveys were entered into the TreeAge program to generate a decision tree (Fig. 1). By convention, calculations within the tree are based on expected complication rates, utility for the health state associated with each complication, duration of the complication, anticipated remaining healthy years of life, and utility for the healthy remaining years of life. Both the decision tree for rheumatologists and the decision tree for hand surgeons show that compared to non-operative management, TWA is the treatment strategy associated with the largest expected gain in QALYs. Surgeon-rated utility for TWA shows a gain of 9.3 expected QALYs compared to non-operative management. Rheumatologist-rated utility for TWA is associated with a gain of 8.1 expected QALYs compared to non-operative management. Evaluation of expected QALYs for TWA compared to TWF shows a difference of 0.9 QALYs for surgeon-rated utility and a difference of 2.7 QALYs for rheumatologist-rated utility

with TWA the more favorable treatment option for both groups.

Sensitivity analysis included manipulation of complication rates and the number of healthy remaining years of life. An increase in the number of healthy remaining years leads to a greater number of expected QALYs for both TWA and TWF compared to non-operative management (Fig. 3). TWA remains a more favorable option than TWF, and the expected gain in QALYs for TWA relative to other options increases with increasing lifespan. Complication rates were also manipulated to determine whether an extremely high complication rate for TWA and an extremely low complication rate for TWF would eventually make TWF the treatment option associated with the highest expected gain in QALYs. We used rheumatologist-rated utility values for this analysis and increased “major complication” rates for TWA while decreasing “major complication” rates for TWF. The altered complication rates and corresponding expected QALYs are presented in Table 3. Increasing the total complication rate for TWA and decreasing the total complication rate for TWF did not result in a change in expected gain in QALYs for either procedure. Even at the extreme theoretical values of a 0% complication rate for TWF and a 100% major complication rate for TWA, TWA remains the more favorable treatment option associated with the highest expected gain in QALYs.

Discussion

Although available for nearly four decades, TWA has failed to gain widespread application, and TWF remains the most popular management strategy for the severely destroyed RA wrist. A recent systematic review of the literature highlights

Figure 3 Sensitivity analysis on healthy remaining years of life. The QALYs for the remaining years of life are plotted for the three treatment scenarios in order to better visualize the dominant treatment choice. Arthroplasty treatment is the dominant choice.

Table 3 Sensitivity Analysis Varying Complication Rates*

Change in Major Complication Rate**	TWA Major Complication Rate† (QALYs)	TWF Major Complication Rate (QALYs)
Baseline	24.2% (25.20)	6% (22.50)
± 20%	29.0% (25.20)	4.8% (22.50)
± 40%	33.9% (25.20)	3.6% (22.50)
± 60%	38.7% (25.20)	2.4% (22.50)
± 80%	43.6% (25.20)	1.2% (22.50)
	100% (25.19)	0% (22.50)

*Calculations include rheumatologist-rated utility values. This sensitivity analysis takes account of the imprecisions in the complication rates derived from the literature. This table shows that despite increasing the complication rates of the dominant strategy (TWA) by 20% increments and concomitant decreasing the complication rates for TWF, TWA will still have higher utility, even when one assumes a 100% complication rate for TWA and 0% complication rate for TWF.

**Complication rates for TWA are increased whereas the rates for TWF are decreased

†TWA major complication rate includes both major complications managed with revision arthroplasty and those managed with salvage fusion

the lack of objective data to compare outcomes of TWA and TWF in the RA wrist [6]. Complication and revision rates seem to be higher for TWA, and improvement in functional status compared to TWF has not been well documented. Failure of TWA to gain widespread popularity may be in part due to rheumatologists' and hand surgeons' opinions about TWA and TWF.

In this decision analytic model, rheumatologists and hand surgeons have a strikingly similar utility for the painful, destroyed rheumatoid wrist. Mean utility values for non-surgical management were 0.57 and 0.54 for rheumatologists and hand surgeons, respectively. These values indicate that physicians responding to our survey view life with a severely destroyed RA wrist as approximately half as valuable as life with a normal wrist. They would theoretically be willing to trade nearly 15 of their remaining 30 years of life in exchange for a painless, well-functioning wrist. This compares similarly with previously demonstrated utility values for diseases such as glaucoma (0.64) [12] and chronic hepatitis (0.50) [18]. Clearly, both groups recognize the impact of severe RA wrist disease on quality of life.

Utility survey results indicate that maintaining wrist mobility is an important consideration, particularly for rheumatologists. Among rheumatologists, mean utility value for uncomplicated TWA was 0.84 compared to 0.75 for uncomplicated TWF. Among hand surgeons, mean utility for uncomplicated TWA was 0.85 compared to 0.82 for uncomplicated TWF. Although both groups show a similar utility for TWA, rheumatologists show a lower utility value for TWF. These differences in mean values are not statistically significant; however, our statistical power was limited due to small sample size, and the trend in our data suggests rheumatologists have a stronger preference for TWA over TWF compared to hand surgeons.

Rheumatologists may find TWF less desirable than hand surgeons because of prior experience with patients who underwent TWF. When surgeons ask a patient about postoperative results, patients are more likely to give a favorable response, even if they are less than satisfied with the outcome. A patient may leave the surgeon's office reporting a fairly successful outcome and then report a much less favorable outcome to his/her rheumatologist. This would certainly lead to a surgeon viewing TWF as a more favorable option than a rheumatologist. Conversely, a surgeon may have more experience with evaluation of long-term hand function after TWF and therefore may be more likely to recognize the ways in which a patient successfully adapts to a fused wrist over time.

TWA is performed much less frequently than TWF. Although nearly 60% of surgeons responding to our survey had performed one or more TWF for RA in the past year, only 19% had performed a TWA for RA. These surgeons may have had negative experiences with TWA in the past or may view TWA as having no functional benefit over TWF based on the lack of convincing published data to support the use of TWA over TWF. Alternatively, surgeons with no experience performing TWA may fail to fully recognize the advantages of the procedure. Given the failure of TWA to gain widespread popularity, rheumatologists likely also have limited experience with patients who have undergone TWA. Mean utility values of 0.84–0.85 for both rheumatologists and hand surgeons indicate that both groups rate living with a TWA as a much less desirable health state than having a normal wrist.

Certainly both rheumatologists and hand surgeons value TWA more highly than they value non-operative management. Factors contributing to these utility ratings may include both the potential for TWA to relieve pain and instability more effectively than non-operative management and the potential for TWA to preserve or restore at least

some wrist mobility. In our decision analytic model, TWA is the management strategy associated with the highest expected gain in QALYs. QALYs provide the basis for cost-effectiveness analyses and can be used to compare the potential benefits of very different treatments that span a broad spectrum of human disease. QALYs are also used in establishing health care priorities. The association of TWA with the highest expected gain in QALYs compared to other operative and non-operative management strategies suggests that allocation of additional research efforts and financial resources to improve TWA is quite reasonable. Rigorous evaluation of current TWA outcomes along with efforts to improve on currently available prostheses may ultimately provide significant gains in quality of life for patients with RA wrist disease.

Although we anticipated the utility for a surgical procedure associated with a complication would be lower than the utility for an uncomplicated procedure, we were surprised to find that neither rheumatologists nor hand surgeons changed their utility ratings based on the increasingly severe complications proposed in our survey. This result may reflect the non-life-threatening nature of the complications of TWA and TWF. In addition, calculation of expected QALYs in a decision model relies heavily on the duration of each health state (Fig. 2). The duration of each health state (complication) for TWA and TWF is minimal compared to the remainder of the patient's life. The expected QALYs calculated for each procedure therefore change very little across the spectrum of possible complications. This finding is reinforced by our sensitivity analysis in which altering the complication rates for TWA and TWF showed no change in the expected QALYs for each procedure even across extreme assumptions.

Measurement of utility relies on assigning health states a relative value between perfect health (utility=1) and death (utility=0). The design of a TTO survey requires the respondent to decide how many years of life (in the health state of interest) would be equivalent to fewer years in a more favorable health state. For life-threatening conditions such as cardiac or renal failure, deciding to give up years of life in a TTO survey may be more intuitive than giving up years of life for a non-life-threatening condition such as rheumatoid wrist disease, although this technique has been applied in many non-life-threatening conditions. For example, living with a surgical site infection, a “minor” complication with no long-term consequences, does not detract from long-term quality of life. One participant commented: “3 months recovering from a [surgical complication] seems small compared to 30 years of function without pain.” Another added: “Rating the value of [a minor complication] to 27 years versus 28 years with a normal wrist is hard to say.” Difficulty in assigning a lifetime sacrifice to relatively temporary surgical complications was undoubtedly a factor in our survey

results. Surgical intervention may improve the RA patient's quality of life by relieving pain and improving function, but TWA and TWF do not offer a survival benefit. Even if physicians believe that TWA and TWF are effective and worthwhile procedures, they may not be willing to give up valuable years of life, and therefore, the utility scores may not fully reflect their opinions about the specific complications of these procedures.

In planning this study, we hoped to gain a better understanding of the factors that have contributed to the slow adoption of TWA. Prior studies have highlighted differences in rheumatologists' and hand surgeons' opinions regarding upper extremity operations for RA [1, 2]. Rheumatologists have considered some surgical interventions to be “delaying strategies” with no long-term effectiveness [16]. They often view surgery as a salvage technique and are hesitant to turn to operative management early in the disease process [4]. Surgeons typically feel that these same interventions are beneficial and have expressed a sense of exclusion from the team approach to RA management. Surgeons report that they are often a “last resort” for RA patients when standard medical management fails [15]. Although the assessment of the utilities of surgeons and rheumatologists is important, patients' opinions are ultimately the deciding factor in selecting a management strategy. We will conduct a prospective cohort study on a group of RA patients with uniform wrist destructive diseases to assess whether patient utility does differ from those from the physicians. We recognize that physician response rates of 30% and 45% are relatively low. However, low response rates are not uncommon when surveying physicians [5]. A 2003 systematic review of internet-based surveys, found response rates as low as 9% among US physicians [5]. Moreover, the complex nature of the time trade-off format increases respondent burden, which also decreases the response rate.

Management of the individual RA patient relies heavily on the opinions and preferences of his/her counseling physicians. We must approach rheumatoid wrist disease as an opportunity for rheumatologists and hand surgeons to collectively advocate for improvements in available treatment strategies. TWA warrants further improvements in design to reduce complication and revision rates. Formal testing of outcomes for TWA compared to TWF will allow not only a rigorous assessment of results but, more likely, will foster a tailored approach to individual patient care. For some RA patients, TWA may be the most favorable option even if shown to have a higher likelihood of future revision. For other patients, TWF may provide excellent function with a single definitive procedure. For the purpose of advancing surgical technologies, the need for ongoing communication between rheumatologists and hand surgeons is paramount. With continued dialogue, these subspecialties can move toward an ideal management of their shared rheumatoid patient population.

Appendix: Utility Survey

Scenario 1:

You have severe RA of the wrist and have 30 years left to live. Your wrist is painful, weak, and unstable, making it difficult to take care of yourself.

If you had to choose between the following options, which would you prefer?

- To live with constant pain and poor wrist function for the remaining 30 years of your life.
- To have well-controlled RA with no wrist pain and good wrist function for X years of life.
- It's too hard to choose.

*Note: For all scenarios, the number of years of life with a painless, well-functioning wrist varies in the online version of the survey. The initial choice is set at 30 years and automatically changes depending on the response selected. The final number of years selected is used for calculating the utility score.

Scenario 2:

You have severe RA of the wrist and have 30 years left to live. Your wrist is painful, weak and unstable, making it difficult to take care of yourself.

If you had to choose between the following options, which would you prefer?

- To undergo a total wrist arthrodesis and live for the remaining 30 years of your life.
- To have well-controlled RA with no wrist pain and good wrist function for X years of life.
- It's too hard to choose.

Scenario 3:

You have severe RA of the wrist and have 30 years left to live. Your wrist is painful, weak, and unstable, making it difficult to take care of yourself.

If you had to choose between the following options, which would you prefer?

- To undergo a total wrist arthrodesis that is complicated by a superficial infection requiring 2 weeks of oral antibiotics. You will live for the remaining 30 years of your life.
- To have well-controlled RA with no wrist pain and good wrist function for X years of life.
- It's too hard to choose.

Scenario 4:

You have severe RA of the wrist and have 30 years left to live. Your wrist is painful, weak, and unstable, making it difficult to take care of yourself.

If you had to choose between the following options, which would you prefer?

- To undergo a total wrist arthrodesis that is complicated by symptomatic hardware requiring removal. You will live for the remaining 30 years of your life.
- To have well-controlled RA with no wrist pain and good wrist function for X years of life.
- It's too hard to choose.

Scenario 5:

You have severe RA of the wrist and have 30 years left to live. Your wrist is painful, weak, and unstable, making it difficult to take care of yourself.

If you had to choose between the following options, which would you prefer?

- To undergo a total wrist arthrodesis complicated by a nonunion requiring repeat fusion with an iliac crest bone graft. You will live for the remaining 30 years of your life.
- To have well-controlled RA with no wrist pain and good wrist function for X years of life.
- It's too hard to choose.

Scenario 6:

You have severe RA of the wrist and have 30 years left to live. Your wrist is painful, weak, and unstable, making it difficult to take care of yourself.

If you had to choose between the following options, which would you prefer?

- To undergo a TWA requiring occupational therapy and a removable splint for about 3 months. You will live for the remaining 30 years of your life.
- To have well-controlled RA with no wrist pain and good wrist function for X years of life.
- It's too hard to choose.

Scenario 7:

You have severe RA of the wrist and have 30 years left to live. Your wrist is painful, weak, and unstable, making it difficult to take care of yourself.

If you had to choose between the following options, which would you prefer?

- To undergo a TWA complicated by delayed healing and requiring dressing changes for 1 month. You will live for the remaining 30 years of your life.
- To have well-controlled RA with no wrist pain and good wrist function for X years of life.
- It's too hard to choose.

Scenario 8:

You have severe RA of the wrist and have 30 years left to live. Your wrist is painful, weak, and unstable, making it difficult to take care of yourself.

If you had to choose between the following options, which would you prefer?

- To undergo a TWA complicated by a hematoma requiring operative drainage. Your wrist will go on to heal with no further complications. You will live for the remaining 30 years of your life.
- To have well-controlled RA with no wrist pain and good wrist function for X years of life.
- It's too hard to choose.

Scenario 9:

You have severe RA of the wrist and have 30 years left to live. Your wrist is painful, weak, and unstable, making it difficult to take care of yourself.

If you had to choose between the following options, which would you prefer?

- To undergo a TWA complicated by loosening of the prosthesis. You require re-operation to replace the prosthesis. Your wrist will go on to heal with no further complications. You will live for the remaining 30 years of your life.
- To have well-controlled RA with no wrist pain and good wrist function for X years of life.
- It's too hard to choose.

Scenario 10:

You have severe RA of the wrist and have 30 years left to live. Your wrist is painful, weak, and unstable, making it difficult to take care of yourself.

If you had to choose between the following options, which would you prefer?

- To undergo a TWA complicated by prosthetic loosening requiring prosthesis removal and total wrist

arthrodesis with an iliac crest bone graft. You will live for the remaining 30 years of your life.

- To have well-controlled RA with no wrist pain and good wrist function for X years of life.
- It's too hard to choose.

Acknowledgements This project was supported in part by the Integra Corporation. The first author is supported by the Robert Wood Johnson Clinical Scholars' Program and the senior author (KCC) is supported by a grant from the National Institute of Arthritis and Musculoskeletal and Skin Diseases (ROI AR047328), a Mid-career Investigator Award in Patient-Oriented Research (K24 AR053120), and an Exploratory/Developmental Research Grant Award (R21 AR056988). We would like to thank Ms. Elizabeth Petruska for her dedicated assistance throughout this project.

References

1. Alderman AK, Chung KC, Demmoner S. The rheumatoid hand: a predictable disease with unpredictable surgical practice patterns. *Arthritis Rheum.* 2002;47:537–42. doi:10.1002/art.10662.
2. Alderman AK, Chung KC, Kim MH, Fox DA, Ubel PA, et al. Effectiveness of rheumatoid hand surgery: contrasting perceptions of rheumatologists and hand surgeons. *J Hand Surg.* 2003;28A 1:3–11.
3. Benson WB, Bensen W, Adachi JD. Back to the future: the pyramids of rheumatoid arthritis. *J Rheumatol.* 1997;24:1023–30.
4. Bird H. Current management of rheumatoid arthritis. *Br J Hosp Med.* 1986;35:374–81.
5. Braithwaite D, Emery J, de Lusignan S, Sutton S. Using the Internet to conduct surveys of health professionals: a valid alternative? *Fam Pract.* 2003;20 5:545–51. doi:10.1093/fampra/cmg509.
6. Cavaliere CM, Chung KC. Systematic review of arthroplasty compared to arthrodesis in the rheumatoid arthritis. *Plast Reconstr Surg.* 2008;122 3:813–25. doi:10.1097/PRS.0b013e318180ece3.
7. De la Mata Llord J, Palacios Carvajal J. Rheumatoid arthritis: are outcomes better with medical or surgical management? *Orthopedics.* 1998;21:1085–6.
8. Detsky AS, Naglie G, Krahn MD, et al. Primer on medical decision analysis: part 1—getting started. *Med Decis Mak.* 1997;17:123–5. doi:10.1177/0272989X9701700201.
9. Divelbiss BJ, Sollerman C, Adams BD. Early results of the universal total wrist arthroplasty in rheumatoid arthritis. *J Hand Surg.* 2002;27A:195–204.
10. Gold MR, Siegel JE, Russell LB, Weinstein MC. Cost-effectiveness in health and medicine. New York: Oxford University Press; 1996.
11. Gomez PF, Morcuende JA. Early attempts at hip arthroplasty—1700s to 1950s. *Iowa Orthop J.* 2005;25:25–9.
12. Gupta V, Srinivasan G, Mei SS, Gazzard G, Sihota R, Kapoor KS. Utility values among glaucoma patients: an impact on the quality of life. *Br J Ophthalmol.* 2005;89:1241–4. doi:10.1136/bjo.2005.068858.
13. Lawrence RC, Helmick CG, Arnett FC. Estimates of the prevalence of arthritis and selected musculoskeletal disorders in the United States. *Arthritis Rheum.* 1998;41:778–99. doi:10.1002/1529-0131(199805)41:5<778::AID-ART4>3.0.CO;2-V.
14. Meuli HC. Arthroplastie du poignet. *Ann Chir.* 1973;27:527–30.
15. Nalebuff EA. Rheumatoid hand surgery: update. *J Hand Surg.* 1983;8A:678–82.

16. Neustadt DH. Evaluation of synovectomy in rheumatoid arthritis. *J Rheumatol*. 1988;15:1874.
17. Roest F, Eijkemans M, Van Der Donk J, et al. The use of confidence intervals for individual utilities: limits to formal decision analysis for treatment choice. *Med Decis Mak*. 1997;17:285–91. doi:[10.1177/0272989X9701700304](https://doi.org/10.1177/0272989X9701700304).
18. Stein K, Dalziel K, Walker A, Jenkins B, Round A, Royle P. Screening for hepatitis C in genito-urinary medicine clinics: a cost utility analysis. *J Hepatol*. 2003;39:814–25. doi:[10.1016/S0168-8278\(03\)00392-1](https://doi.org/10.1016/S0168-8278(03)00392-1).
19. Swanson AB. Flexible implant arthroplasty for arthritic disabilities of the radiocarpal joint. *Orthop Clin North Am*. 1973;4:383–92.
20. Torrance GW. Preferences for health outcomes and cost-utility analysis. *Am J Manag Care*. 1997;3:S8–20.
21. Volz RG. The development of a total wrist arthroplasty. *Clin Orthop Relat Res*. 1976;116:209–14.