Long-Term Health-Related Quality of Life Outcomes in Digital Replantation versus Revision Amputation

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J Reconstr Microsurg 2017;33:446–451.

Abstract

Background Earlier, digit viability judged the success of digital replantation. Now, utility health-related quality of life (HRQOL) measures can better assess the impact of digital replantation.

Methods Overall, 264 digital injury patients were sent a regimen of utility measures: Disabilities of the Arm, Shoulder and Hand (DASH) score, European Quality of Life 5 Dimensions, visual analog scale (VAS), time trade-off (TTO), and standard gamble (SG). Overall, 51 patients responded completely to all of these—36 replantation patients and 15 revision amputation patients. The utility results of these patients were stratified between replantation versus revision amputation; dominant hand replantation versus nondominant hand replantation; and dominant hand revision amputation versus nondominant hand revision amputation.

Results The mean VAS score of replant (0.84) and revision amputation (0.75) groups was significantly different ($p = 0.05$). The mean DASH score of dominant hand replantations (29.72) and nondominant hand replantations (17.97) was significantly different ($p = 0.027$). The dominant hand revision amputation had higher anxiety levels in comparison to nondominant hand revision amputation ($p = 0.027$). Patients with two or more digits replanted showed a significant decrease in VAS, TTO, and SG scores in comparison to patients who only had one digit replanted ($p = 0.009$, 0.001, and 0.001, respectively).

Conclusions This study suggests that HRQOL can offer better indices for outcomes of digital replantation. This shows some specific replantation cohorts have a significantly better quality of life when compared with their specific correlating revision amputation cohort. These findings can be employed to further refine indications and contraindications to replantation and help predict the quality of life outcomes.

Keywords
- digital replantation
- utility
- hand
- revision amputation

received
November 4, 2016
accepted after revision
February 9, 2017
published online
March 22, 2017

DOI https://doi.org/10.1055/s-0037-1601052.
ISSN 0743-684X.

Digital replantation survival rates were long believed to be approximately 90%, however, new studies argue that number is actually substantially lower near 57%.[1–5] Many outcome parameters of digital replantation could benefit from further analysis; however, obtaining large volumes of data regarding health-related quality of life (HRQOL) outcome measures has been elusive. The factors dictating a patient's experience and satisfaction with replantation are nebulous: length of hospital stay, costs incurred, time away from work and lost wages, the length of rehabilitation required, as well as psychological and cosmetic considerations.[6,7] Translating these parameters into HRQOL is difficult. For example, does a 70% restoration of original function improve the quality of life, or does a significant threshold of improvement begin at 90%? Further, establishing validated HRQOL outcome measures in replant patients may allow for greater econometric analyses for this resource intense undertaking.

Utility HRQOL measures can better capture the impact of different treatments on a patient's functional outcome. The European Quality of Life 5 Dimensions (Euro-QoL-5D/EQ-5D) —is an indirect quality of life survey that is brief and easy to administer—composed of five simple questions assessing pain, anxiety, mobility, self-care, and ease of activities—that has been validated in many health states and surgical conditions.[8,9]

Patient's responses to these questionnaires allow investigators to calculate general HRQOL scores for a specific disease state, which is especially useful in assessing the effects of a heterogeneous illness or injury or effects of these states in heterogeneous patient populations. In a similar fashion, health utility outcomes are another standardized tool physicians use to directly assess the subjective experiences of various health states. One of the most respected analytical tools of patients' quality of life after upper extremity injury is the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire. It is an assessment of global functioning in patients with upper extremity pathology. The questionnaire is comprised of 30 subjective questions designed to assess a patient's health state in regards to the upper limb taking into account function, symptoms, quality of life issues related to upper extremity pathology, and is scored on a scale of 0 to 100 with 100 being the worst.[10,11]

Using multiple scores such as visual analog scale (VAS), time trade-off (TTO), and standard gamble (SG), the investigator is in a better position to obtain a more accurate assessment of the impact a disease or health state has on the quality of life of the patient. One year is considered the postbias period for utility testing in chronic conditions and this period was surpassed before utility testing was conducted.[12]

The present study assesses the HRQOL of patients who have presented to the Quebec Replant Program. Patients who had sustained a digital injury were contacted, and the HRQOL as measured by the Euro-QoL, DASH, VAS, TTO, and SG scores was compared between various cohorts of replantation or revision amputation patients.

Methods

This study consisted of patients who suffered a digital injury of the upper extremity and then qualified for transfer to the Quebec Replant Center for revaluation and subsequent digital replantation or revision amputation between April 2004 and April 2007 based on the current indications for digital replantation surgery. The initial pool consisted of 264 patients. Of these, DASH questionnaires were mailed to 262 patients during July 2007. The timeframe for responses lasted 4 months to November 2007, during which 151 questionnaires were returned. Patients who responded to the mailed DASH survey were then contacted via telephone at least 1 year after responding to the DASH survey during which a direct interview was conducted focusing on evaluating the patient's quality of life via Euro-QoL, DASH, VAS, TTO, and SG utility measures. Throughout this entire process, a retrospective database was constructed with the patient data including, handedness, occupation, demographics, medical and surgical history, and other pertinent patient information. After completion of the process, 51 patients had responded and completed the DASH questionnaire and utility measures phone interview.

The VAS used here ranged from 0 to 100, where 0 corresponds to the worst imaginable state of health and 100 denotes the perfect state of health. A higher score denotes a higher quality of life. SG is a hypothetical scenario where the patient is offered a hypothetical procedure with probability "P" that would return the patient's state of health to normal, yet with a probability "1 − P" of certain death. The point of indifference between the two scenario probabilities is denoted as P, therefore, a higher score denotes a higher quality of life. TTO is another hypothetical scenario presented to the patient. The patient is told about the situation that they have 10 years of life left in their current state of health; however, they can sacrifice several of these years in exchange for living the remainder life in perfectly normal state (e.g., "If I only have 10 years to live in my current state of health, I would rather only live 4 years if it was with perfect health"). The decision is then translated into a ratio (in the example $4/10 = 0.4$). Once again, a higher number denotes a higher quality of life.

Analysis began by comparing the outcome measures between the replant group and the amputation group via a Wilcoxon rank-sum comparison test analyzing the measures described by the Euro-QoL. A simple *t*-test was then performed to compare the DASH scores of the two groups. Finally, a simple *t*-test was done to compare the utility results (VAS, TTO, and SG) of the two groups.

The next step of analysis began by stratifying the replant patients into two groups: those who had replantation on their dominant hand, and those who had replantation on their nondominant hand. A Wilcoxon rank-sum comparison test was performed to analyze the measures described by the Euro-QoL. A simple *t*-test was then performed to compare the DASH scores of the two groups. Finally, a simple *t*-test was done to compare the utility results of the two groups.

The final step of analysis began by stratifying the nonreplant (i.e., revision amputation) patients into two groups: those who had revision amputation on their dominant hand, and those who had revision amputation on their nondominant hand. A Wilcoxon rank-sum comparison test was performed to analyze the measures described by the Euro-QoL. A simple *t*-test was done to compare the DASH scores of the two groups. Finally, a simple *t*-test was performed to compare the utility results of the two groups.

Results

The study sample consisted of 51 patients—46 males and 5 females—with a mean age of 53.9 years (range: 19–74 years). Overall, 36 were replantation patients and 15 were revision amputation patients. There was no statistically significant difference in the proportion of patients receiving revision amputation or replantation in the study group. There was also no statistically significant difference in age or hand dominance between revision amputation and replantation cohort sizes (►**Table 1**).

In comparing the replant group ($n = 36$) and revision amputation group ($n = 15$) there were no statistically significant differences between the two groups' Euro-QoL scores: mobility, self-care, activities, pain, or anxiety (►**Table 2**). The mean DASH score for the replant group and revision amputation group was 24.02 and 21.89, respectively, with no statistically significant difference (►**Table 3**). When comparing utility results of the two groups there was no statistically significant difference between the replant group and revision amputation group in terms of TTO and SG. However, the VAS score for the replant group and revision amputation group was 0.84 and 0.75, respectively, with a statistically significant difference ($p = 0.05$) (►**Table 4**).

In comparing the dominant hand replant group ($n = 24$) and nondominant hand replant group ($n = 12$) there was no difference between the two groups' Euro-QoL scores (►**Table 2**). The mean DASH score for the dominant replantation group and nondominant replantation group was 29.72 and 17.97, respectively, with a statistically significant difference ($p = 0.027$) (►**Table 3**). When comparing the utility results of the two groups there was no statistically significant difference (►**Table 4**).

In comparing the dominant hand revision amputation group ($n = 6$) and nondominant hand revision amputation group ($n = 9$) there was no statistically significant difference in regards to their Euro-QoL scores, except for anxiety ($p = 0.027$), which suggests that a patient feels more anxiety about a revision amputation on their dominant hand (►**Table 2**). The mean DASH score for the dominant amputation group and nondominant amputation group was 34.31 and 25.72, respectively, with no statistically significant

Table 1 Average age, and cohort statistics

	Average age (y, range)	Dominant hand	Nondominant hand	Total
Amputation	53 (21–75)	6	9	15
Replantation	52.9 (19–74)	24	12	36
Total		30	21	

Table 2 Euro-QoL score comparison using Wilcoxon rank-sum comparison test

	Replantation vs. amputation (*p*)	Dominant replantation vs. nondominant replantation (*p*)	Dominant amputation vs. nondominant amputation (*p*)
Mobility	0.88	0.61	0.22
Self-care	0.95	0.60	0.69
Activities	0.15	0.92	0.34
Pain	0.99	0.55	0.11
Anxiety	0.076	0.67	0.027

Abbreviation: Euro-QoL, European Quality of Life.

Table 3 Mean DASH score comparison via simple *t*-test

Mean DASH score					
Amputation	21.89	Dominant replantation	29.72	Dominant amputation	34.31
Replantation	24.02	Nondominant replantation	17.97	Nondominant amputation	25.72
p	0.19		0.027		0.50

Abbreviation: DASH, Disabilities of the Arm, Shoulder and Hand.

Table 4 Mean utility score comparisons via simple *t*-test

	Mean VAS	Mean TTO	Mean SG
Amputation	0.75	0.88	0.86
	0.84	0.92	0.83
	0.72	0.85	0.85
Replantation	0.84	0.86	0.84
	0.84	0.82	0.85
	0.77	0.90	0.87
p	0.05	0.72	0.81
	0.92	0.23	0.87
	0.62	0.63	0.92

Abbreviations: SG, standard gamble; TTO, time tradeoff; VAS, visual analog scale.

difference between the two groups (►**Table 3**). The utility testing showed no significant difference between the two groups (►**Table 4**).

Discussion

This study is a long-term retrospective review of patients with more than 1 year of follow-up assessing multiple accepted HRQOL measures and is the first study of a significant patient population size postinjury and rehabilitation. While no absolute indications for replantation can be concluded, in this study it is demonstrated that quality of life improvements are significantly higher in certain replantation groups when compared with their revision amputation counterparts. Average DASH scores in dominant hand replantation patients were significantly higher than average DASH scores in nondominant replantation patients. More exciting is that replantation patients altogether had a significantly higher VAS in comparison to revision amputation patients. These findings can be used to guide indications for replantation in the future, and help prepare surgeons to anticipate patient outcomes in certain replantation circumstances.

At the inception of replant surgery in 1973, O'Brien et al summed up the measure of success: "the primary aim in replantation of a digit is to obtain survival. The other equally important aim is to achieve satisfactory function."[13] However, as the field evolved the focus shifted to objective criteria such as total active range of motion, power, sensation of the replanted digit, and ability of the patient to return to work.[14] However, the atmosphere of medical literature now encourages analysis of the HRQOL of a patient to judge the effectiveness of a procedure. Utility theory represents a group of economic game theory-derived HRQOL assessment tools designed to help quantify uncertainty in medicine.[15–17] These types of tests have been used extensively in medicine over the past 50 years and have proven to be a reliable indicator of patient quality of life for a multitude of various diseases and injuries over a broad spectrum of health field.[18–20] Utility studies have also been implemented in various health care decision-making algorithms and for optimal allocation of resources.[21]

When analyzing a patient with digital amputation a surgeon must consider many characteristics about the injury: location, mechanism, time of injury, baseline health state of the patient, patient occupation, age, and handedness to name a few. This results in very few absolute indications and contraindications for digital replantation. The few consensuses for indication of replantation include: any degree of amputation of the thumb; single digit amputation at level distal to insertion of flexor digitorum superficialis, ring avulsion injuries type II or IIIa; amputations of multiple digits; amputations at midpalm level; and amputations in pediatric patients.[22–24] However, exceptions to these rules do occur when the profession of the patient requires great dexterity of the hand, when the degree of injury makes replantation technically unfeasible, or in multiple digit injuries when priority must be given to restoring high priority function. Furthermore, the goal of replantation may change based on the digits involved: ulnar digit replantation focusing on range of motion and radial digit replantation focusing on stability. HRQOL indices may be useful in analyzing digital injuries since the nature and degree of these injuries varies so wildly. Strongly demonstrated HRQOL improvements can be sued as a better measuring tool for outcome satisfaction to define more concrete indications and contraindications to digital replantation.

Based on previously reported patient preferences it would seem that replant is viewed as subjectively more desirable than revision amputation, however, our experience seems to speak otherwise. With a consistent trend of no significant difference in HRQOL indices between our replant patient group and revision amputation patient group—it is suggested that digital replantation does not always correlate with an improved quality of life. It seems that the satisfaction of the patient and the preservation of quality of life does not hinge on whether the patient undergoes replantation or amputation, but rather that these outcomes are heavily decided by the nature of the injury itself: whether the patient's dominant or nondominant hand is injured, number of digits involved, location of the injury, and severity of the injury. In regards to nature of the initial injury, it has been demonstrated that as the number of digits replanted increases, this correlates with lower utility scores. The mean utility scores of patients who had one to five replanted digits were analyzed via analysis of variance and upon a comparison of patients who had one digit replanted or two or more showed a significant difference in the VAS, TTO, and SG scores ($p = 0.009, 0.001, 0.001$) (►**Fig. 1**). One may venture to say the outcome is largely predetermined at the time the initial trauma is suffered.

Resource competition is increasingly salient in today's medical environment. The appropriate allocation and utilization of resources—time, money, medical supplies, and effort—is a constant theme of national and health care system policy. Tax funded expenditures for health care in the United States totaled $1.87 trillion in 2013, and are

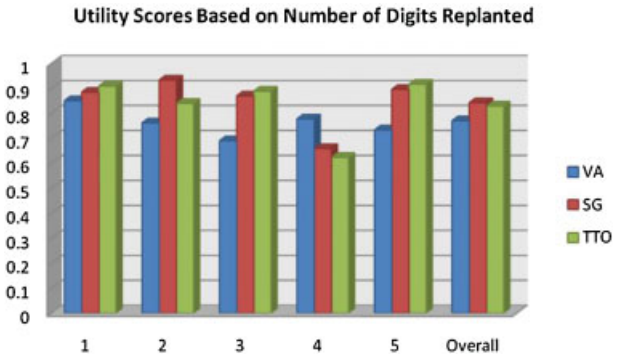

Fig. 1 Utility scores based on a number of digits replanted.

expected to increase to $2.81 trillion by 2020 causing increased pressures for efficiency and cost justification.[25] In one study in 1987 analyzing 47 digital replantations in 21 patients, it was calculated that total cost per replantation of one lone digit cost $17,000—taking into account surgeon's fee, operating room fees, postoperative hospital stay, and rehabilitative hand therapy regimen.[25] Adjusting for inflation this cost translates to approximately $35,000 (in the fiscal year 2015) per replantation of a single digit. The substantial cost of replantation surgery coupled with the findings presented in this study that quality of life improvements from replantation is dubious certainly questions the necessity of replantation and numerous indications for the procedure. Given the initial findings of this study, paired with poorer outcomes of digital replantation than previously thought, and along with the hybrid model of improving patient quality of life while also being cognizant of costs one could ponder whether digital replantations should be as widely implemented as they are currently.

Minor limitations exist such as lack of control group and retrospective nature of this study, however, this study can be acknowledged as a valid initial investigation that can be improved upon by utilizing a larger sample and diligently encouraging a more uniform and complete patient response rate. Overall, sample size limits the study's power that may mask significant finding. The sample size of the replantation cohort is more than twice that of the amputation group. This study occurred at an institution prominent in digital replantation to which these patients were transferred. Patients were transferred to this institution in the hopes of meeting criteria and receiving a replantation. Essentially, introducing selection bias to this study. The purpose of this selecting out was so as not to subject a patient to a compromised, costly, and essentially futile procedure—however, this process resulted in the respective sample sizes found within. In addition, the ultimate decision for replantation was the decision of the surgeon so various personal proficiencies and confidence are certain procedures in certain injuries may influence the sorting of patients into cohorts. Furthermore, the overall heterogeneity of our patient population in terms of pathology may not yield critical patient cohorts that would benefit more from replantation over other groups. However, what is noteworthy is that these critiques mirror the digital replantation patient group as a whole—a small number of patients undergo this procedure annually and the patients themselves range in variety. Another limitation to mention is the variability in patient understanding and comprehension of questionnaires being administered. Administration of the utility testing was performed directly with the patient on the phone to try and to curtail any misunderstanding that would sway results. Another limitation to be acknowledged is in regards to patient response: only 51 of the initial 264 patients responded fully to the surveys administered. One must keep in mind: are patients more likely to respond to surveys if unpleased with their quality of life, or pleased with their quality of life, or simply feel strongly about it in either respect?

A major characteristic of this study is that the subjective nature of the patients' self-assessment of their quality of life is the main variable being analyzed. A self-assessment of the overall quality of life hinges on the intrinsic psychological schema the patient is in when answering questions pertaining to quality of life. Gocke et al concluded that the psychology of the patient should be considered during assessment of patients after replantation, as well as should be used as a tool to help guide treatment.[26] Galanakos et al further bolster this though stating that treating the patient as a whole—physical and mental—may have profound effects on improving a patient's quality of life after reconstruction of the upper extremity.[27] The quality of life assessments are a barometer of physical and mental well-being, self-perception of present conditions and expectations of the future, visible and invisible variables.

Conclusion

This study attempted to apply well-used quality of life measurement parameters in regards to digital replantation. This is the first type of study in which patients were asked to answer utility assessment questionnaires—under direct investigator supervision—1 year after digital replantation or revision amputation. While no definitive conclusions can be drawn from this study as it stands, it brings to light the question whether the indications for digital replantation are as conclusive as the surgical community currently believes. It also demonstrates another purpose of this study that is, directly analyzing digital replantation outcomes using HRQOL utility measures. This study may be viewed as a useful initial investigation upon which further studies into the benefits of digital replantation can be built.

Conflict of Interest
None.

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