

Patient engagement in cosmetic designing of prostheses: current practice and potential outcome benefits

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Abstract

Background: Making a prosthesis for an individual with limb loss is a highly personalized process. A currently unexplored area is whether there are tangible benefits in greater patient engagement during the cosmetic designing of their prostheses. We examined the current clinical practice of engaging patients in prosthetic cosmetic designing and identified factors associated with patient outcomes.

Methods: One hundred and four prosthetists and 28 prosthesis users were surveyed in this cross-sectional study. The questionnaires covered aspects of prosthetic prescription and fabrication, users' perceived level of engagement, and self-reported outcomes. Regression analyses were used to examine the associations between patients' perceived levels of engagement during the design process, satisfaction, and other outcomes.

Results: Seventy-five percent of the prosthesis users reported being offered at least one cosmetic option during the making of their prostheses, which corroborated with 82.7% of the prosthetists reporting that they typically engage their patients in this aspect of their practices. Patients who were offered at least one cosmetic design option reported significantly greater satisfaction ($P = 0.027$) than those who were not offered such an option. Patients' level of satisfaction regarding the look of their prostheses was significantly correlated with their perception that their prostheses empower them in daily activities ($r = 0.415$, $P = 0.028$).

Conclusion: Engaging patients in the cosmetic designing of their prostheses is a widely accepted practice. Patients who are more satisfied with the look of their prostheses perceived higher levels of empowerment. Prosthetic practitioners should consider the potential outcome benefits of higher level engagement for users of prosthetic devices.

Keywords

lower limb amputation, prosthesis, cosmesis, autonomy support, survey study, empowerment

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Introduction

Amputation is a life-altering, traumatic experience that can affect many facets of an individual's life.¹ Loss of a limb segment and the associated muscles/tissues not only physically affects the patient's functioning, but it often also results in emotional stress and reduction of overall quality of life.² In the United States alone, there are currently more than 2 million people living with amputations, with about 185,000 more occurring each year.³ With this large and

ever-growing population, there is an increasing need to understand how to improve patient outcomes after amputation.

One currently unexplored area is whether there are tangible benefits in engaging patients during the decision-making process regarding the cosmetic and functional componentry choices when fabricating their prostheses. All prostheses are custom fabricated to fit the shape of the patient's residual limb; however, some prosthetists solicit higher degrees of input from their patients, such as on cosmetic features (i.e. color and artistic/graphical designs), protective/cosmesis covers, and other prosthetic components.⁴ Higher levels of engagement during this process may support patients' autonomy and improve their body image, which have been shown to be decreased in patients with limb amputations.^{2,5}

Satisfying one's fundamental need for autonomy, even in providing seemingly incidental choices, has been shown to improve motor skill performance, learning, and self-efficacy.⁶⁻⁸ For example, Wulf et al⁶ showed that by offering a choice of ball color during a throwing task (i.e. a choice unrelated to task performance), participants' throwing accuracy was significantly improved. The performance improvement carried over to skill transfer, retention, and enhanced self-efficacy, indicating that such benefits are profound.⁷ As applied to prosthetics, being given the opportunity to participate in the cosmetic design of one's prosthesis could bring tangible benefits to the prosthesis user. Furthermore, amputees have to adapt to alterations in body image, which is the perception of one's appearance.^{1,9,10} Previous studies

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have shown that body image is significantly correlated with prosthetic satisfaction.¹⁰ Therefore, it is logical to believe that engaging amputee patients in the cosmetic designing of their prostheses may benefit prosthetic satisfaction, utilization, and other outcomes. However, this premise is currently unexplored.

The purpose of this study was to examine the following: 1) the current practice and factors that influence whether patients with limb loss are given the opportunity to provide input to the design options of their prostheses, 2) whether being involved in designing the appearance of one's prosthesis is related to more positive patient self-reported outcomes. We hypothesized that greater involvement in the making of one's prosthesis would result in psychological benefits and improved outcomes.

Methods

The study protocol was approved by the "IRB for Biomedical Research at the University of Nevada, Las Vegas". Cross-sectional surveys of prosthetists and amputee patients were conducted between August 2019 and February 2020.

Prosthetists survey

The prosthetists survey used in this study was a 12-item questionnaire that queried about their current practice of offering prosthetic design options to patients (Appendix 1, Supplemental Digital Content, <http://links.lww.com/POI/A84>). Questions included whether and why they typically offer or do not offer certain design options, the types of cosmetic options they typically offer (i.e. color, artistic/graphic design, shell/cover, and other), populations they perceive to be more likely to request or to whom they are more likely to offer the options, and whether the prosthetists perceive any outcome differences in patients who received a prosthesis with their chosen design options. All participants in this survey were currently practicing prosthetists.

Prosthesis users' survey

The 20-item prosthesis users' survey focused on questions related to perceived level of engagement during the fabrication of their prostheses and the users' perceptions regarding their prosthetic device and other outcomes (Appendix 2, Supplemental Digital Content, <http://links.lww.com/POI/A84>). Specific outcomes included prosthetic usage (i.e. daily and weekly wear time) and perceptions regarding how one's personal prosthesis looks, works, and empowers the patient to do what they like to do. The inclusion criteria were individuals who were aged 18 years and older, experienced a major lower limb loss (defined as losing at least one major joint), and owned a working prosthesis for at least 6 months. The exclusion criteria were nonprosthetic users and presence of any condition that can interfere with the participant's ability to understand and answer the questions written in simple English.

Both questionnaires were created and validated by experts in prosthetics, rehabilitation, and human behavioral science and a group of prosthesis users. The surveys were administered using an online platform (Qualtrics, Provo, UT) advertised through the Orthotics and Prosthetics Listserve, prosthetic companies' websites, a local Amputee Patient Support Group (Las Vegas Amputee

Support Group), prosthetic and rehabilitation services in the region, and personal communications.

Data analysis

For the prosthetists survey, the primary variable of interest was whether the cosmetic design options are typically offered (by the prosthetist in question) in their practice (Q2, Appendix 1, Supplemental Digital Content, <http://links.lww.com/POI/A84>). We explored predictors for a positive response to this question using a logistic regression model. Secondary analyses examined in depth the open-ended responses from prosthetists regarding the practice of offering the prosthetic cosmetic options to their patients. Prosthetists were asked, "Why do you typically offer cosmetically customized prosthesis to a patient?" The responses to this question were grouped into four categories; patient-driven, prosthetist-driven, cost-related, and other reasons. Examples of patient-driven responses included the following: "it is the patient's leg, it should look the way they want it to", and "people get more joy and show off their prosthesis if they are excited about how it looks." The prosthetist-driven category contained responses that were related to the prosthetist's beliefs; examples of such responses included: "[prosthetic] covers protect components...", and "it may increase compliance". Cost-related responses were grouped if the responses were related to insurance coverage or lower out-of-pocket costs to the patient. Examples of this included the following: "only a few insurance companies deny cosmetic coverage..." and "it's easy and inexpensive." Responses in other category included the following: "It is a service we provide to all patients. Standard operating procedure." The reasons for not typically offering the cosmetic options to their patients were also analyzed using the same four categories of responses. Such responses included the following: "[cosmesis] inhibit component function and are a pain to make" (prosthetist driven) and "usually not paid for by insurance, patients don't usually want to pay" (cost-related).

For the prosthesis users surveyed in this study, aspects of perceived involvement during the prosthesis-making process were described using descriptive statistics. To further investigate potential predictors of patients receiving prosthetic options during fabrication, a regression model was applied to examine its association with sex and time after amputation because a previous study has shown that female individuals were more likely to receive cosmetic covers for their prostheses.¹¹ Further analyses focused on comparing the self-reported outcomes between individuals who were given at least one option vs. those who were not (Q11: "Were you given an option to customize your prosthesis?"). We examined the correlations between the perceived levels of involvement and satisfaction toward their prostheses and other patient-reported outcomes using bivariate Pearson correlation.

To further examine the effects of specific cosmetic design options on patients' self-reported outcomes, we applied the weighted quantile sum (WQS) regression model to condense the prosthetic options into a mixture variable and to simultaneously evaluate the mixture effect on each self-reported outcome item.¹² The weight of each prosthetic option on the mixture effect reflects the contribution of that prosthetic option to the overall effect. A total of 100 bootstrapping steps were performed to make the estimated

coefficient of the mixture effect more robust. A τ value from the reciprocal of the number of prosthetic options was used to determine whether a weight of a prosthetic option had a positive contribution greater than the default weight.

SPSS, version 26 (IBM SPSS Statistics, International Business Machines Corp, New York) was used to compute descriptive statistics, Pearson correlations, and logistic regression models. RStudio, version 1.3.1056 (RStudio, PBC, MA) was used to perform the WQS regression analysis. The significance level for all analyses was set at 0.05.

Results

Prosthetists survey results

A total of 104 complete responses were received from practicing prosthetists. Most prosthetists reported that they solicit input from their patients (91.3%, $n = 95$), and 82.7% of the prosthetists confirmed that they typically offer at least one cosmetic design option to their patients. Patient-driven factors were the leading reason to offer those options (64.0%). Within the prosthetists who reported that they do not typically offer cosmetic options ($n = 18$), cost-related (33.3%) and prosthetist-driven (38.9%) factors were the leading reasons. Some prosthetists said that they are more likely to offer the cosmetic options to certain populations (Table 1). Of the prosthetists who considered age as a deciding factor, 69.6% said they were more likely to offer cosmetic options to younger patients vs. 30.4% to older patients. The prosthetists who considered sex as a deciding factor indicated that they were more likely to offer the option to female patients (73.3%). Other populations that the prosthetists would consider when offering the design options to included race and cultural groups, patients with special needs, and patients with better insurance. The logistic regression analysis showed that the prosthetist's estimated percentage of their patients who choose to have a cosmetically customized prosthesis (Q7, Appendix 1, Supplemental Digital Content, <http://links.lww.com/POI/A84>) was the only significant predictor of whether a prosthetist would offer such options to his/her patient ($P = 0.001$).

A high percentage of the prosthetists (69.2%) reported that they noticed positive differences in patients who own a prosthesis with customized design options. Specifically, the noted differences included more positive attitude, improved motivation, compliance, and function (Table 1).

Prosthesis users survey results

A total of 28 current prosthesis users participated (Table 2). On average, the participants were 8.8 ± 9.8 years after their amputation at the time of study. Most prosthesis users (78.6%) said that they felt engaged in the design of their current prostheses, of which 95.5% said that they were given at least one cosmetic design option (color, artistic/graphic designs, cosmesis shell/cover, and other). On average, the prosthesis users surveyed rated their level of engagement at 77.6 ± 28.8 on a scale of 0–100. Regarding the question “*how important is the look of your prosthesis?*” the average score was 76.8 ± 29.2 out of 100. The regression analyses were unable to find any patient characteristics that predict whether they received a cosmetic design option. Particularly, our

model showed that gender and years after amputation were not significant predictors ($P = 0.462$ and 0.175 , respectively).

Comparisons between those who were ($n = 22$) and were not ($n = 6$) offered at least one cosmetic design option showed that participants who were offered the options place significantly higher importance on the looks of their prostheses (yes-option = 83 ± 25.1 vs. no-option = 53.8 ± 34.0 , $P = 0.027$). Correlation analyses showed that the level of importance participants place on the looks of their prostheses was significantly correlated with their perceived levels of involvement during fabrication ($r = 0.488$, $P = 0.008$), and how much the cosmetic aspect of the device determines whether they use their prostheses ($r = 0.597$, $P = 0.001$). Our analyses further showed that a patient's satisfaction regarding the look of his/her prosthesis was significantly correlated with their levels of perception that their prostheses empower them to do things they like to do ($r = 0.415$, $P = 0.028$). The perceived level of empowerment from their prostheses was also significantly correlated with the number of hours they report they can comfortably wear the prostheses ($r = 0.443$, $P = 0.018$), the level that they look forward to wear the prosthesis everyday ($r = 0.564$, $P = 0.002$), and the overall satisfaction regarding how their prostheses works ($r = 0.859$, $P < 0.001$).

WQS analyses showed that giving input to different cosmetic options (i.e. color, graphics, and shell/cover) has variable levels of effect on different outcomes (Table 3). In general, giving input to color and cosmesis shell/cover design options exhibited relatively higher weighed effects than graphics design options regarding the self-reported outcomes.

Discussion

Our findings showed that most prosthetists engage their patients in the design process, specifically more than 80% typically offer at least one cosmetic design options to their patients. This was confirmed by our finding that 75% of the surveyed prosthesis users stated that they were offered at least one cosmetic design option during the fabrication of their personal prostheses. Consistent with experimental findings that choice promotes positive affect and intrinsic motivation,^{13,14} almost 70% of the surveyed prosthetists reported that they noticed more positive attitude, improved motivation, compliance, and function in patients who owned a prosthesis with customized cosmetic design options. This also agreed with our findings that prosthesis users' level of satisfaction regarding the looks of their prostheses was significantly related to whether they feel the prostheses empower them and their overall satisfaction. The findings from our research help to elucidate how seemingly decorative prosthetic options can have psychological benefits that translate to potential positive outcomes for prosthesis users.

Our results showed that soliciting inputs from patients is an integral part of prosthetic prescription and fabrication. Most if not all prosthetic devices are individually customized to fit the patient's needs, including comfort, function, and cosmesis. The results from the prosthetic practitioners surveyed in this study reflected this practice principle, mostly to satisfy the patients' needs and preferences. However, some practitioners were more likely to offer design options to certain patient populations. A number of prosthetists reported that they are more likely to offer cosmetic design options to patients who are younger or female individuals.

Table 1. Summary of the prosthetist survey results.

Question	N	%
Do you typically offer cosmetically customized prostheses to a patient?		
Yes	86	82.7
No	18	17.3
Why do you typically offer cosmetically customized prostheses to a patient?		
Patient-driven reasons	55	64.0
Prosthetist-driven reasons	35	40.7
Cost-related reasons	6	7.0
Other	10	11.6
Who is the population that you are more likely to offer a cosmetically customized design or a higher level of design option to?		
Age	23	22.1
Pediatric	5	21.7
Younger adult	16	69.6
Older adult (older than 50 years)	7	30.4
Sex	15	14.4
Female	11	73.3
Male	4	26.7
Other populations	13	12.5
Between patients who have and do not have custom-designed prosthesis, do you notice a difference?		
Yes	72	69.2
No	32	30.8
What are the differences you notice between patients who have and do not have a prosthesis with cosmetic design?		
Motivation	22	21.4
Attitude	33	31.7
Compliance	18	17.3
Function	9	8.7
Other	13	12.5

These biases corresponded with the findings from Highsmith et al¹¹ that female patients with lower limb loss were more likely to receive a cosmesis cover than male individuals. Prosthetists' implicit bias toward this practice may result in lost opportunities in gaining the benefits associated with greater engagement and choice.¹³ Personal values such as sex (e.g. feminine or masculine), professional, cultural, and other attributes should be considered for all prosthesis users.^{15,16} Interactions between prosthetists and prosthesis users during and beyond prosthetic fabrication and whether the professional relationship affects patient outcome should be explored more in depth in future studies.

For prosthetists who reported that they do not typically offer prosthetic cosmetic options, cost-related and prosthetist-driven factors were the leading reasons behind this opinion. The cost-related factor should be considered in light of insurance coverage; certain payers consider cosmesis to be irrelevant to function and may deter prosthetists from offering such options. For example,

Table 2. Demographic characteristics of the prosthesis users (N = 28).

Variable	N	%
Age distribution		
30–39	4	14.3
40–49	3	10.7
50–59	11	39.3
60–69	8	28.8
70+	2	7.1
Sex		
Male	17	60.7
Female	11	39.3
Ethnicity		
White	15	53.3
African American	6	21.4
Asian American	1	3.6
Hispanic/Latino	5	17.9
Native American	1	3.6
Cause of amputation		
Trauma	6	21.4
Cancer	4	14.3
Vascular/arterial disease (including diabetes)	7	25.0
Congenital reason	2	7.1
Other	3	10.1
Declined to answer	5	18.5
Level of amputation		
Transfemoral	5	17.9
Transtibial	6	21.4
Bilateral lower limb	2	7.1
Upper limb	2	7.1
Other	1	3.6
Declined to answer	12	42.9

Medicare in the United States typically only pays for components that can be justified to offer protection to the prosthesis (i.e. shells or covers) and not purely cosmetic.¹⁷ The prosthetist-driven reasons involved the prosthetists' beliefs that adding certain cosmetic components such as the cosmesis cover can disrupt the normal function of a prosthesis. A previous study by Cairns et al revealed that up to 64% of the prosthesis users expressed less than satisfied opinions regarding their cosmesis cover. Specifically, 43% of them were less than satisfied by how their prosthesis cover influenced prosthetic joint movement for those with an above-the-knee amputation.¹⁸ This corroborates with comments from the prosthetists in our study that adjustment difficulty, disruption of component function, and durability were their main concerns regarding cosmesis covers. Although efforts were made to improve the look and function of cosmesis covers,¹⁹ this cosmetic option is likely one of the less offered in current prosthetic clinical practice.

In the current literature, the priority between prosthetic form and function remains debatable. A systematic review conducted by

Table 3. Mixture effects of giving input to different cosmetic options on patient outcomes.

	Cosmetic options		
	Color	Graphics	Shell/cover
Motivation to wear the prosthesis everyday	0.24 ^a	<0.01	0.40 ^a
Empowerment by prosthesis	0.27 ^a	0.01	0.24 ^a
Satisfaction on how prosthesis works	0.18 ^a	<0.01	0.37 ^a
Satisfaction on how prosthesis looks	0.27 ^a	0.01	0.24 ^a
Level of involvement during prosthesis-making process	0.09	0.02	0.35 ^a

^aDenotes statistically significant effects (relative weight > 0.17). A higher value indicates greater relative effect of the cosmetic option to the corresponding outcome.

Ritchie et al²⁰ showed that users of upper limb prostheses often view function as more important than cosmesis. Nevertheless, the look of one's prosthesis was unlikely to be completely unimportant to the user because satisfying prosthesis users' needs in cosmesis have long been the guiding principle in prosthetic prescription and fabrication. We found that most prosthetists offer cosmetic options to satisfy their patient's preferences. Many prosthetists mentioned "fun," "personal expression," and "acceptance" when asked why they typically offer cosmetic options to their patients. This ubiquitous practice adopted by most prosthetists may implicitly provide support to their patients' autonomy.

The benefits of autonomy support have been demonstrated in several recent studies. Lewthwaite et al⁷ showed that giving participants choices unrelated to the task, that is choice of a painting to hang on the wall just before the participant performing a balance task, can lead to improved performance and motivation. The leading theory behind this effect is that supporting an individual's sense of autonomy can improve self-efficacy, positive affect, and motivation.¹⁴ Autonomy support can be viewed as the practice of fostering an environment that emphasizes an individual's ability to make their own choices, which can be easily achieved by engaging patients in the design process of their prostheses. Our findings supported this premise since participants' satisfaction regarding the look of their prostheses was significantly correlated with how they saw their prostheses empowering them during activities. Furthermore, the perceived level of empowerment from their prostheses was significantly correlated with their actual prosthetic usage time and motivation to wear the prosthesis.

If patients with limb loss are more motivated to wear their prosthesis, it is reasonable to believe that such behavior can lead to better functional and health outcomes in the long run because they would be more inclined to be physically active and participate in higher levels of activities necessary to their social roles. These empowering acts do not have to involve costly componentry decisions. If clinicians can see the value of supporting patients' autonomy, they can capitalize on these tangible benefits without incurring significant monetary or time costs. Prosthetists should consider opportunities more broadly in engaging patients in all facets of their practices.

Limitations

The number of prosthesis users interviewed for this study was limited (n = 28). Although this number is larger than some of the previous studies on this topic,⁵ the survey was conducted regionally and based on a sample of convenience, both of which

may limit the generalizability of the study findings. A larger study controlling these potential confounding factors is needed to further explore the effect sizes of different prosthetic cosmetic options on outcomes in individuals with limb loss. Cultural differences may also need to be considered in future investigations of this topic.

Conclusion

High percentages of prosthetists and persons with limb loss reported offering and receiving design options on prosthetic cosmesis, indicating that this is an ubiquitous practice. Offering cosmetic options and supporting patients' autonomy involve little to no risk in clinical prosthetic practice while showing tangible benefits. This study provides evidence supporting prosthetists to engage their patients during the prosthesis-making process because it has the potential to drive patient empowerment and motivation.

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