Predictors of Continued Prosthetic Wear in Children With Upper Extremity Prostheses

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ABSTRACT

The purpose of this study was to determine whether age at initial fit, type of prosthesis, geographic location, gender, or side of limb deficiency were associated with duration of upper extremity prosthetic wear in children. A retrospective chart review of 298 children was conducted at five Shriners Hospitals for Children to determine which factors contributed to longer duration of prosthetic wear in children who were fit with transradial prostheses between 1988 and 1998. Data analysis was performed to answer the following questions: (1) Does age at initial fit or initial type of prosthesis affect prosthetic outcome (defined as more than 3 years of wear)? (2) Does current or final type of prosthesis affect prosthetic outcome? (3) Does geographic location or distance traveled to the clinic affect prosthetic outcome? (4) Does side of limb deficiency or gender affect prosthetic outcome? Children fit with a transradial prosthesis at younger ages wore a prosthesis longer than did children fit at older ages. For current or final type of prosthesis, children who wore a body-powered or myoelectric prothesis were more than two times as likely to wear it $>$ 3 years than were children who wore a passive prosthesis. Finally, children living in Mexico were more than three times as likely to wear a prosthesis $>$ 3 years than were children living in other countries. Initial type of prosthesis, distance traveled to the clinic, gender, or side of limb deficiency were not correlated with duration of prosthetic wear. Age at initial fit, current or final type of prosthesis, and geographic location were predictors that correlated with longer duration of prosthetic wear in children wearing transradial prostheses. (*J Prosthet Orthot*. 2005;17: 119–124.)

KEY INDEXING TERMS: transradial prosthesis, child amputee, arm prosthesis, artificial arm

Upper extremity prosthetic wear in children is dependent on various factors, and it is difficult to determine which factors contribute to a successful prosthetic outcome. Clinicians make decisions regarding prosthetic management based on past experience and limited research. There are different opinions on treatment guidelines and protocols for fitting a child with a transradial prosthesis. Children often are fit with a prosthesis according to the preferences of the clinicians or families, and as a result, children are fit at different ages with different types of prostheses.

A passive, myoelectric, or body-powered prosthesis can be prescribed for children who choose to wear a transradial prosthesis. Children also have the option of not wearing a prosthesis. Comparison studies of various prostheses produce different results, depending on how the comparison was made and what specific factors (e.g., activities, wear, timed tasks) were measured.[1–5] From these studies, there are no conclusive indicators as to which type of prosthesis contributes to continued prosthetic wear and use. However, in a recent study, Crandall and Tomhave[6] reported that children who are offered multiple prosthetic options wear for longer periods than do children who are prescribed only one type of prosthesis.

In terms of age at initial fit with a prosthesis, Scotland and Galway[7] and Brooks and Shaperman[8] concluded in their studies that higher rejection rates occur when children are fit after the age of 2 years. Others have found higher rejection rates in children older than 13 years of age.[7,9] These studies suggest that it is preferable to fit the child at younger ages.

Prosthetic outcome has been measured in previous studies by assessing whether the child is wearing a prosthesis after a specified amount of time. Rejection rates of 10% to 50% for upper-extremity prostheses have been reported.[3,4,7,9] Differences in these results could be attributable to the population sampled (type and level of limb deficiency or amputation, small sample size), the methodological approach of the study, or the clinical philosophy for treatment. Postema et al.[9]

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contend that rejection is higher when there is a perceived lack of functional gain along with parental dissatisfaction. Identifying factors that are important in achieving and maintaining prosthetic wear may help guide the clinical care of the child who chooses to wear a prosthesis.

This retrospective study of children fit with transradial prostheses attempts to identify factors associated with longer duration of prosthetic wear. For this study, prosthetic outcome was defined as wearing a prosthesis for more than 3 years.

METHODS

A total of 298 chart reviews were completed at five Shriners Hospitals for Children: Erie (26), Houston (52), Los Angeles (143), Montreal (7), and Twin Cities (70). Criteria for inclusion consisted of children with a unilateral congenital transradial deficiency who were fit with a prosthesis between 1988 and 1998. Therapists at the hospitals used available database records and clinic lists to determine eligible subjects for chart reviews. Data collection included basic demographic information (gender, side of limb deficiency, date of birth, area of residence), prosthetic history and current (2001) prosthetic status. Personal identification was removed, and institutional review board approval for exempt status was obtained because direct patient contact and interviewing were not used in this study. Specific data collected included distance traveled to the hospital (measured in miles), date of first prosthetic fitting, type of first prosthesis, wearing status as of 2001, final type of prosthesis (current or last worn), and number of years of prosthetic wear if not wearing in 2001. Therapists identified current status of prosthetic wear as wearing, not wearing, and questionable wear. The reason for questionable wear was recorded (for example, did not return to the clinic for follow-up).

Data analysis was performed to answer the following questions:

1. Does age at initial fit or initial type of prosthesis affect prosthetic outcome, which was defined as more than 3 years of wear?
2. Does current or final type of prosthesis affect prosthetic outcome?
3. Does geographic location or distance traveled to the clinic affect prosthetic outcome?
4. Does side of limb deficiency or gender affect prosthetic outcome?

The study sample consisted of 166 females and 132 males, 188 of whom had a unilateral congenital transradial deficiency on the left side, and 110 on the right side. Most of the children (229) lived in the United States at the time of data collection; 58 lived in Mexico, and 11 lived in other countries. For the type of first prosthesis issued, 104 used a body-powered prosthesis with voluntary opening system (BPVO), 14 used a body-powered prosthesis with voluntary closing system (BPVC), 15 used a myoelectric prosthesis, and 6 used a passive prosthesis. Of the remaining 158 children (fit at age younger than 2 years), 52 used a passive infant prosthesis with a terminal device with a movable part (Pf) and 106 used a passive infant prosthesis with a terminal device with a nonmovable part (Ph). The infant passive functional terminal device (Pf) was defined as a device with a movable part (i.e., CAPP TD, TRS L'il E-Z Infant Hand, hook). The infant passive cosmetic terminal device (Ph) was defined as a "hand" with no movable parts (foam-filled hand, mitt, hand with cosmetic glove). A passive prosthesis was designated for the older child. For the type of current (last) prosthesis: 147 wore a BPVO, 69 wore a BPVC, 44 wore a myoelectric prosthesis, and 28 wore a passive prosthesis. Ten children did not progress past their infant prostheses: six were last wearing a Pf and four were last wearing a Ph.

Patients were stratified into two groups based on duration of prosthetic wear: ≤ 3 years versus >3 years. The 3-year criterion was chosen because this was thought to be clinically significant in terms of length of time for the child to develop consistent and continued wear. The dichotomized measure of prosthetic wear was analyzed in association with gender, side of limb deficiency, geographic location, miles traveled to the hospital, child's age at initial fit, type of prosthesis at initial fit, and type of prosthesis currently wearing or last worn.

Logistic regression analysis was used to investigate the association between the dependent variable, which in this case is the duration of prosthetic wear, and the independent variables (gender, side of limb deficiency, geographic location, miles, age at initial fit, and prosthesis type). A series of unadjusted logistic regression models were first developed for each of the independent variables. Logistic regression analysis computes odds ratios and models the log odds of the dependent variable as a linear function of the independent variables. Odds ratios greater than 1.0 signify a positive association. Odds ratios less than 1.0 designate a negative relationship with duration of prosthesis wear. Measures found to be significant ($p \leq 0.05$) were entered into a multiple logistic regression model to determine independent predictors of prosthetic wear duration. The adjusted model then examines the contribution of each variable in relationship to duration of prosthetic wear by controlling the influence of the other variables.

RESULTS

There was a significant relationship with continued prosthetic wear for children living in Mexico (Table 1). Children who reside in Mexico were more than three times more likely to wear a prosthesis at least 3 years than were children from other countries (odds ratio [OR] = 3.47, $p = 0.000$). A negative relationship was found between age of initial fit and prosthetic wear (OR = 0.91, $p = 0.002$), meaning that children fit at younger ages wore the prosthesis for a longer period. An association was found for continued prosthetic wear when body-powered was identified as the current (final) type of prosthesis. Children who wore a body-powered prosthesis were almost three times as likely to wear a prosthesis

Table 1. Unadjusted logistic regression analyses for greater than 3 years prosthesis wear

	Odds Ratio	*P* Value
Female vs. male	1.06	0.818
Left side vs. right side	0.72	0.173
Mexico vs. other countries	3.47	**0.000**
Miles traveled to hospital	1.00	0.189
Age at First Fit	0.91	**0.002**
Prosthesis at first fit		
Passive	1.0	—
Myoelectric	0.57	0.305
Body Power	0.98	0.927
Final prosthesis		
Passive	1.0	—
Myoelectric	2.27	0.077
Body Power	2.87	**0.005**
Infant prosthesis		
Ph vs. Pf	1.16	0.66

for >3 years than were children who wore a passive prosthesis (OR = 2.87, $p = 0.005$). Duration of wear approached statistical significance ($p = 0.077$) for current or final myoelectric prosthesis versus a passive prosthesis. Gender, side of limb deficiency, distance traveled, and type of prosthesis at first fit were unassociated with duration of prosthetic wear.

Measures found significantly related to duration of wear at the binary level of analysis remained significant in the multivariate model. The adjusted logistic regression analysis found age at initial fit, geographic location, and current (final) type of prosthesis associated with duration of prosthesis wear (Table 2). Geographic location was a strong independent predictor of duration of wear. Children living in Mexico were more than 4.5 times more likely to continue wearing a prosthesis >3 years than were children living in other countries (OR = 4.69, $p = 0.000$). Children initially fit with a prosthesis at older ages were less likely to wear the prosthesis for >3 years (OR = 0.88, $p = 0.000$). Finally, children were more than two times as likely to wear a prosthesis >3 years when current or final fit was a body-powered prosthesis (OR = 2.36, $p = 0.029$) or myoelectric prosthesis (OR = 2.96, $p = 0.027$), rather than a passive prosthesis.

Table 2. Adjusted logistic regression analyses for greater than 3 years prosthesis wear

	Odds Ratio	*P* Value	95% CI
Mexico vs. Other Countries	4.69	0.000	2.27–9.66
Age at First Fit	0.88	0.000	0.82–0.94
Final Prosthesis Type			
Passive	1.0	—	
Myoelectric	2.96	0.027	1.13–7.74
Body Power	2.36	0.029	1.09–5.09

Descriptive characteristics of the population studied are summarized for reference in Table 3 and Figure 1. One hundred fifty-three (53%) children had worn a prosthesis for >3 years and continued to wear a prosthesis in 2001. Forty-five (15%) children were currently not wearing a prosthesis; however, for this study of duration of wear, 27 of the non-wearers had worn a prosthesis for at least 3 years. Ninety-five (32%) children had questionable prosthetic wear, and 51 of the questionable wearers had worn a prosthesis for at least 3 years. In total, 236 (79%) children wore a prosthesis for >3 years, and 62 (21%) children wore a prosthesis ≤3 years.

DISCUSSION

Treatment philosophy for fitting children with transradial prostheses varies from clinic to clinic. Many clinicians advocate early fitting and, in a recent survey conducted by Shaperman et al.,[10] infants are generally fit with a first passive prosthesis when they have achieved independent sitting balance. In this retrospective study, 86 (88%) infants (younger than 1 year) wore a prosthesis >3 years and continue to wear (Table 3). These results suggest that either a passive hand or a functional terminal device can be used on the infant's first prosthesis. There were no differences observed between the two infant terminal devices on long-term prosthetic wear (Table 1, $p = 0.66$). It is clinically more important for the infant or child to develop a consistent full-time wearing and use pattern.[11,12]

Children initially fit with a transradial prosthesis at older ages are less likely to continue to wear a prosthesis. If fitting is delayed, the child becomes accustomed to performing activities without a prosthesis and may not be motivated to learn new skills that are necessary for incorporating a prosthesis into daily activities. Older children begin to become more skillful, establish patterns, and develop natural methods to accomplish tasks, making it more difficult to introduce a prosthesis. Because this study focused on duration of prosthetic wear, it would be beneficial to evaluate how children's use patterns and skill levels influence prosthetic outcome. Clinically, it is observed that the child's prosthetic needs, use, and skills change with age, and these developmental changes also affect outcome.

In the current study, children who were last wearing a body-powered or myoelectric prosthesis were doing so for a longer duration than were children who were last wearing a passive prosthesis. Most clinics generally fit infants with a passive prosthesis and progress to a more "active" type of prosthesis.[10] The body-powered prosthesis provides functional benefits (assisted grasp), is lightweight, and is easy to use. The myoelectric prosthesis provides a combination of functional (motor-driven assisted grasp) and cosmetic benefits but is heavier and more expensive. Young children can easily learn how to operate a body-powered or a myoelectric prosthesis. It takes additional

Table 3. Descriptive characteristics according to number of years worn and status

Duration of prosthetic wear	More than 3 years of prosthetic wear			Less than 3 years of prosthetic wear		
Current status (2001)	Yes wearing	Not wearing	Questionable wear	Not wearing	Questionable wear	Total
Total number	158	27	51	18	44	298
Male	69	11	27	6	19	132
Female	89	16	24	12	25	166
Left	94	13	36	10	35	188
Right	64	14	15	8	9	110
US residence	107	23	48	15	36	229
Outside US residence	51	4	3	3	8	69
Average distance in miles to hospital	329.2	167	305.6	216	125.8	228.7
Average age in years of first prosthesis fit	2.7	3.3	3.1	3.8	6.3	3.8
Final prosthesis type						
BPVC	46	3	17	0	3	69
BPVO	77	14	21	6	29	144
Myoelectric	23	5	7	5	4	44
Passive	12	5	6	2	3	28
Infant (Ph)	0	0	0	3	1	4
Infant (PF)	0	0	0	2	4	6
Initial prosthesis type						
Body power	1					1
BPVC	9	3	2	0	0	14
BPVO	54	10	11	4	25	104
Myoelectric	6	0	3	4	2	15
Passive	2	0	1	0	3	6
Infant (Ph)	59	8	26	7	6	106
Infant (Pf)	27	6	8	3	8	52

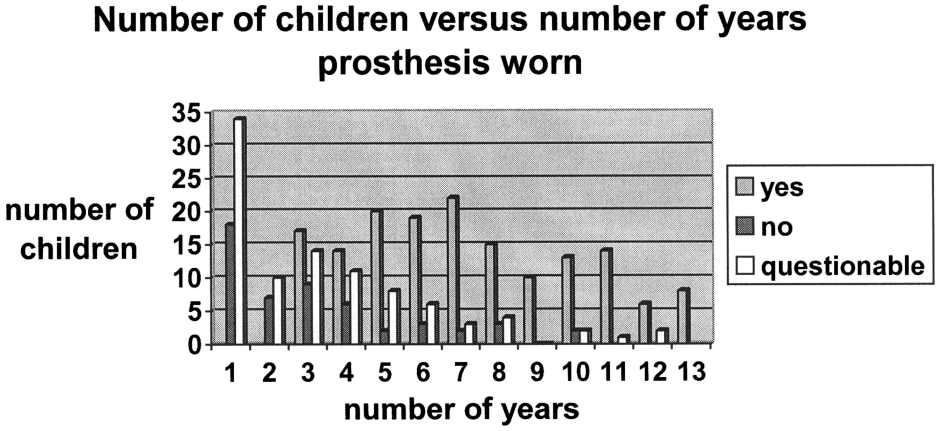

Figure 1. Total number of years of prosthetic wear and status.

practice to learn various skills to use any type of prosthesis in a functional and spontaneous manner.[13] Some families are more interested in the cosmetic aspects of a prosthesis, and this issue was not investigated as a factor in continued prosthetic wear. Teenagers are often fit with a passive prosthesis that provides cosmetic restoration and some functional benefit.[14] Each prosthesis has advantages and disadvantages, and selecting the best type to meet the changing needs of the child is a challenge.

Many of the children in the current study initially were fit with an infant passive prosthesis and later were fit with a body-powered prosthesis, so results must be analyzed in terms of this population. Clinicians in the Shriners Hospitals for Children system vary in their philosophical approach and treatment of children with limb deficiencies. In their decision for prosthetic fitting, clinicians consider the cost of the prosthesis, the distance the family lives from the clinic, and whether or not a family can maintain a certain type of

prosthesis. The child's developmental needs and psychosocial concerns are also taken into consideration when determining what type of prosthesis is the most beneficial.[11,12]

Children from Mexico have a greater tendency to wear a prosthesis for 3 years or longer. It can be theorized that this result is related to cultural differences in how families from Mexico view the usefulness or necessity of a prosthesis. In support, several studies have reported that parental and child satisfaction and prosthetic usefulness are important elements for continued wear.[9,15–17] The cultural differences, along with other reasons for prolonged wear in this population, need additional investigation.

There appears to be some benefit to the 236 (79%) children who wore a prosthesis for at least 3 years. Ultimate "rejection" was carefully avoided in this study because not continuing to wear a prosthesis should not be assessed as a failure or as a negative outcome. It is clinically observed that a prosthesis cannot meet or fulfill all of the needs of the family or child. It may be an appropriate outcome or natural occurrence for a certain percentage of children to find the prosthesis unnecessary. A prosthesis may not meet all the child's need, but it may serve a short-term purpose or benefit during a certain developmental period.[12]

The current project was made possible by the assistance of several therapists who identified data through chart review. Recorded documents (data) are often subject to error, and such errors may be present in the current study. Attempts were made to accurately record and gather all relevant data. To reduce errors and to find objective conclusions, several individuals conducted independent statistical analyses. In determining current prosthetic status, therapists assigned one of three categories: wearing, not wearing, or questionable. Forty-four children had questionable status and were identified as wearing less than 3 years. These children had not returned to the hospital for follow-up visits, were discharged from hospital services, or had moved. It was assumed that if the child was still wearing a prosthesis, he or she would need an annual clinic appointment. It is possible that a percentage of these children received assistance outside the hospital system and may have continued to wear a prosthesis. However, for this study, those children who had this questionable status (identified with less than 3 years of wear) were categorized to obtain results that were not biased toward prosthetic wear.

Numerical values were relatively small for certain categories, and care must be taken when generalizing. The categories with larger numbers and significant differences can be incorporated into the clinical decision-making process. Additional factors not identified or measured in this study also may have profound effects on continued wear. Motivation, cognitive and motor planning ability, prosthetic skill attainment, length of residual limb,[4,7] and family commitment are important components in prosthetic wear and were not measured in this study.

Not fitting a child with a prosthesis may be the best treatment plan for some families. Factors that may lead to a choice of no prosthesis include children who find no functional benefit with prosthetic use and children who have other difficulties, such as learning problems, psychosocial issues, and motor coordination problems. Families that cannot follow through or commit to a prosthetic program should reconsider having their child fit with a prosthesis. Children easily adapt and use their residual limb in a natural, functional manner. It takes a great deal of training and commitment for a child to use a prosthesis spontaneously and for a long duration.

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