Newsletter

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Endoskeletal Prostheses; Cause for Reflection

Charles H. Pritham, C.P.O.*

American prosthetists have now accumulated a decade of experience with endoskeletal modular prostheses. In light of this experience, it seems logical to reassess the criteria and priorities that guided the development of this method of providing prosthetic care. If one were to choose two events more than others that marked the beginning of the "new era," they would have to be the introduction in the Fall of 1970[1] of the Otto Bock endoskeletal system and the convening in March 1971 by CPRD of a workshop entitled, "Cosmesis and Modular Limb Prostheses"[2]. Few are unfamiliar with the features of the Otto Bock system and they hardly need to be commented on here. Suffice it to say that the system undoubtedly represents the highest possible physical expression of the modular endoskeletal concept. The second development referred to, the CPRD workshop, is probably less familiar and merits closer attention, especially so since the report from the workshop states the philosophy of the endoskeletal modular approach to limb prosthetics.

That philosophy finds its fullest and most concise exposition in the remarks of D.S. McKenzie, M.D.[2], Table I. As he saw it, components would be produced by a central manufacturer and shipped to outlying fitting centers through the aid of an elaborate and well-developed inventory system. A patient would essentially be issued with a basic complement of components necessary to meet his functional demands and this, with periodic replacements for update and repair, would constitute his prosthesis for the rest of his ambulatory life. Capability for modifying alignment would be built into the prosthesis, all components would be completely interchangeable, and all modifications, minor or major, would be effected while the patient waited. The prosthesis was to be fully cost-competitive with a conventional prosthesis, no heavier, and offer superior cosmesis. The only custom-made or "bespoke" component of the prosthesis was to be the socket, although the possibility of prefabricated and readily adjustable sockets was envisaged. The total delivery system was to be so all-encompassing and versatile that it would be only occasionally necessary to fabricate an "on-off" prosthesis. In addition, he envisaged the development of smaller components for children and of lighter weight components for geriatrics.

In other sections of the report, the CPRD workshop recommended improvements in cosmetic covers and prosthetic skins and development of endoskeletal upper limb prostheses employing center-pull cables and external power. Indeed, so sanguine were the attendees at the workshop about the future of endoskeletal modular limb prostheses that they essentially recommended that all future development be done in this context.

Comparison of expectation with reality is very difficult in this situation as there is very little in the literature that describes field experience with endoskeletal modular prostheses. What information there is[3], is largely anecdotal but it suggests that the problems encountered focus on weight and poorer durability than conventional exoskeletal prostheses. The upshot is that endoskeletal prostheses are fundamentally considered luxury items to be prescribed for light-activity, appearance-conscious wearers. Wider-spread acceptance has primarily occurred with hip disarticulation prostheses due to ease of fabrication and favorable weight competitiveness compared to conventional means of construction.

It seems fair to conclude, therefore, that anyone who subscribed to the criteria developed in the CPRD workshop of 1971 would be disappointed with the rate of acceptance and continued improvements in endoskeletal prosthetic systems during the past decade. It is convenient to ascribe this failure to intransigent con-

*Formerly Director, Prosthetic and Orthotic Laboratory, Rehabilitation Engineering Center, Moss Rehabilitation Hospital, Philadelphia, PA. Presently Manager, Snell's of Louisville, Louisville, KY

servatism on the part of the third-party payers and of individual prosthetists. Perhaps a more proper explanation can be found in the precepts that shaped the development of the prostheses themselves.

Endoskeletal modular prosthetic systems are intended by their very nature to encompass the needs of the vast majority of amputees. In effect, they represent a series of compromises: strong enough for all but the most punishing of patients and yet light enough for all but the most feeble of patients, etc. Anything or anyone who attempts to be all things to all men generally ends up satisfying no one. In this regard a fundamental fact about the nature of the amputee population needs to be acknowledged. The primary cause of amputation in western society is disease and this primarily affects the older age group. Comparison of amputee censuses[4] bears this out. Moreover, with declining birth rates and increased longevity, the age of the population in general is shifting to the higher decades. The one trend reinforces the other and we may confidently expect in the years ahead that even more of our patients will be 65 or over with circulatory disorders and multiple involvement. It is widely admitted that the needs of the geriatric amputee are different from the needs of the younger amputee. Sophisticated knee and ankle function become less important, and light weight, comfort, and ease of donning become more important. In effect, the nature of the amputee population and the precepts guiding development of prostheses have changed, but prosthetists and developers of prostheses have been slow to recognize the change. In part this is due to the fact that the needs of geriatrics are mundane and prosaic as compared to the challenge offered in designing a high performance, sophisticated prosthesis for a young vigorous user who uses a prosthesis maximally and thus offers maximum positive reinforcement to the designer.

Another matter that deserves consideration is the concept that it should be readily possible by changing components or alignment to adapt the prosthesis to the changing needs of the amputee and that the same prosthesis that serves him 24 hours after surgery will still be suitable 24 months after surgery. Reference here is made to Table 1 where the different stages in the experience of an amputee are listed vertically and the various possible features of a prosthesis are listed horizontally. Advocates of the first viewpoint, such as D.S. McKenzie, would have it that at any given moment in the experience of an amputee, all possible features are present. Advocates of the second view would have it that for the sake of expediency, low weight, cost, durability, and other considerations, only those features absolutely necessary at any one stage of development would be present—in effect that form follows function. For example, while quick-disconnect of the pylon and foot from the socket is suitable and even necessary in an immediate post-operative prosthesis (I.P.O.P.), it is unnecessary and a possible source of trouble in a definitive prosthesis. An advocate of this second point of view might fill out the table much as it has been done.

Central to this discussion is the question of what is an acceptable range of alignment adjustability at any one stage. Few would dispute that full range of alignment adustability is necessary in I.P.O.P.s and temporary prostheses. Less unanimity greets the statement that it should be present in definitive prostheses. Some would maintain that it is not necessary in definitive prostheses

	Features of Prosthesis					
Prosthesis to be fit, as a factor of time subsequent to amputation	**Quick Disconnect**	**Interchange of Components**	**Full Alignment Adjustability**	**Minimum Alignment Adjustability**	**Temporary Cosmesis**	**Durable Cosmesis**
I.P.O.P. 0 - 6 weeks	X		X			
Short-term temporary 6 wks. - 3 mo.		X	X			
Long-term temporary 6 wks. - 6 mo.		X	X		X	
Definitive The first to be fit subsequent to a temporary prosthesis and to have a suitable life-span of 12 - 18 mo. Subsequent definitive prostheses to be changed every 2 - 3 years		X		X		X

TABLE 1

and that, in any event, some range of adjustability (height, transverse rotation of foot, and in some cases, of the knee) is present and that this is all that is necessary in the vast majority of cases. They would further maintain that any increase in alignment adjustability represents an unacceptable increase in weight and decreases in reliability. Moreover, they would have it that should you have to change any of the other factors of alignment, something is so seriously wrong as to warrant starting over again completely from scratch. This second point of view is exemplified most strikingly in the Adaptive Fixation Prosthesis (A.F.P.) system of Medical Center Prosthetics of Houston, Texas.

There is one final topic that merits discussion and that is the matter of cosmesis. Current techniques of providing cosmetic covers entail the carving of internal and external contours and are expensive and time consuming. Moreover, it is questionable as to whether or not the results merit the effort, as the covers for all levels of amputation are flimsy. For above-knee and higher, the one-piece covers inhibit function. Support hose currently used as prosthetic skins are even less durable, yet attempts to provide stronger skins have been defeated by the need to accommodate the extreme motion of the knee. (It remains to be seen whether it will be possible to devise successful one-piece cosmetic covers for above-knee prostheses with current technology or if we will eventually sacrifice some of the cosmesis of one-piece covers and adopt two-piece covers and improved durability.) Again, the work of Medical Center Prosthetics and their technique for foaming cosmetic covers in place are noted.

In conclusion, it is possible to pose a number of questions:

1. Do available endoskeletal prosthetic systems meet the needs of the majority of amputees as well as do exoskeletal prostheses?

2. If they do, why are they not used with greater frequency than casual impression seems to imply that they are?

3. Is it desirable to use a common family of endoskeletal components at all stages of an amputee's progress post-amputation or can an increase in desirable qualities be achieved by more specifically matching the available components and the individual's progress?

4. Is it desirable and necessary to have full capability for alignment adjustability present in a definitive prosthesis or can some adjustability be sacrificed to decrease weight and heighten reliability?

5. If cosmetic covers were better than they are, would more endoskeletal prostheses be prescribed? Or is it that if more endoskeletal prostheses were prescribed, better cosmetic covers would be developed?

The present group of endoskeletal systems (with one exception) can be considered as first generation systems. Extensive experience has been gained with them and it seems reasonable to assess this experience with an eye towards developing criteria for second generation systems. Further, it seems only just that those personnel who have day-to-day experience be canvassed in developing these criteria.

References

1. *Below-Knee and Above-Knee Prostheses*, Committee on Prosthetic Research and Development, National Academy of Sciences, Washington, D.C. 1973, page 21.
2. *Cosmesis and Modular Limb Prostheses*, Committee on Prosthetic Research and Development, National Academy of Sciences, Washington, D.C. 1971.
3. Wilson, A. Bennett, Jr., "Lower Limb Modular Prostheses, A Status Report," *Orthotics and Prosthetics*, Vol. 29, No. 1, pp. 23-32, March 1975.
4. Kay, Hector W. and Newman, June D., "Amputee Survey 1973-74, Preliminary Findings and Comparisons," *Orthotics and Prosthetics*, Vol. 28, No. 2, pp. 27-32, June 1974.

Meetings and Events

Please notify the National Office immediately concerning additional meeting dates. It is important to get meeting notices in as early as possible. In the case of Regional Meetings, check with the National Office prior to confirming dates to avoid conflicts in scheduling.

1982, February 4—6, AAOP Annual Meeting and Round-up Seminar, Fairmont Hotel, New Orleans, Louisiana.

1982, March 2—6, Boston Scoliosis Brace Course, sponsored by The Children's Hospital Medical Center of Boston. Course site: Cincinnati, Ohio.

1982, April 16—17, AOPA Region I Meeting, Marriott Hotel, Worcester, Massachusetts.

1982, April 29—May 2, AOPA Regions VII, VIII, X and XI Combined Meeting, Alameda Plaza, Kansas City, Missouri.

1982, May 6—9, AOPA Region IV Meeting, Radisson Plaza Hotel, Nashville, Tennessee.

1982, May 10—13, Advanced Course on Below-Knee and Through-Knee Amputations and Prosthetics, ISPO, Copenhagen, Denmark.

1982, May 27—29, AOPA Region V Meeting, Charleston House, Charleston, West Virginia.

1982, June 4—6, AOPA Region IX, COPA, AAOP California Chapters Combined Annual Meeting, Harrah's, South Lake Tahoe, Nevada.

1982, June 10—13, AOPA Regions II and III Combined Meeting, Claridge Hotel, Atlantic City, New Jersey.

1982, June 17—20, AOPA Region VI and AAOP Midwest Chapter Combined Meeting, Indian Lakes Resort, Bloomingdale, Illinois.

1982, September 8—10, Second Annual Advanced Course of Lower Extremity Prosthetics, Nassau County Medical Center, East Meadow, New York.

1982, October 17—24, AOPA National Assembly, Shamrock Hilton, Houston, Texas.

1983, May 12—14, AOPA Regions II and III Combined Meeting, Colonial Williamsburg, Williamsburg, Virginia.

1983, June 3—5, AOPA Region IX, COPA, AAOP California Chapters Combined Annual Meeting, Harrah's, South Lake Tahoe, Nevada.