Conclusions of a Conference on Linkage Feeders

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FOLLOWING the preparation of the *Preliminary Design Analysis of Linkage Feeders* by Prosthetic and Orthotic Studies of New York University (J), it seemed desirable to explore the significance of the design similarities and differences identified in the NYU report.

Accordingly, a Workshop on Linkage Feeders was organized and conducted under the auspices of the Subcommittee on Evaluation of the Committee on Prosthetics Research and Development. Participants in the workshop conference, which was held at the University of Michigan, Ann Arbor, Mich., July 26-27, 1965, included representatives from the five centers whose feeder designs were discussed in the NYU analysis, plus unattached engineering and other consultants.[2]

At the conference, the design and applications of linkage feeders were discussed in considerable detail, both with respect to the major components (chair-attachment assemblies, proximal and distal links, rocker-arm assemblies, and troughs) and the device as a whole. In the following presentation of major points emerging from the discussions, it will be noted that while there were areas of disagreement, a community of agreement on many considerations was evident.

ADJUSTMENT

AVAILABILITY TO THE PATIENT

A characteristic of the University of Michigan and the Rancho Los Amigos Hospital systems is that provisions for adjustment are retained throughout the life of the orthoses. At the other centers, apparently, a temporary feeder is used initially, with adjustments made during the course of training by physician, therapist, or orthotist. Before the patient leaves the center, the optimal adjustments are frozen, so to speak, in a permanent unit.

A basic difference in philosophy is evident here. The belief at the University of Michigan is that the patient's family can be taught to adjust the feeder and should have the privilege of doing so; for example, to accommodate changes in the status of the patient's muscular torques with time. The belief at the other centers is that the optimal feeder geometry established during training may be lost with patient-family manipulation.

Since proponents of both approaches are apparently satisfied with the results achieved, no categorical rule would appear to apply. To the impartial observer, retention of adjustability would seem desirable with, perhaps, provision for locking the adjustment features, if this restriction were found necessary.

PRECISION

Theoretically—and perhaps actually—the threaded-screw adjustments of the University

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[2] Persons attending the workshop were: Herbert Elftman, Sidney Fishman, as *co-chairmen;* Edward Haak, James Poulson, of the Georgia Warm Springs Foundation; Robert C. Juvinall, James W. Rae, Jr., Edwin M. Smith, of the University of Michigan; G. Hartmann, Nancy Verdon (Appoldt), of New York University; Alice Garrett, Patrick Marer, Betty Yerxa, of Rancho Los Amigos Hospital; Thorkild Engen, of Texas Institute of Rehabilitation and Research; Linda Parker, Randolph Witt, of Texas Rehabilitation Center; Hans A. Mauch, Colin A. McLaurin, Eugene F. Murphy, as engineering consultants; Hector W. Kay, James R. Kingham, A. Bennett Wilson, Jr., of the staff of the Committee on Prosthetics Research and Development. (Mr. Wilson also served as an engineering consultant.)

of Michigan model provide the means for securing more precise adjustments than any of the other units.

There appears to be no question that the provision of an efficient system of balances and biases is critical to the patient's performance and increases in importance with the extent of disability.

There is, however, considerable question concerning the degree of precision achieved or required in these units. Since motion of the forearm in the trough shifts the center of gravity of the forearm in relation to its axis of rotation, as do objects of different weights held in the hand, optimal adjustment would seem to be dynamic rather than static. Moreover, desired adjustments are in relation to a particular configuration of trough and rocker-arm assembly, for example, and this configuration itself may not represent the optimal design. It is noteworthy, though, that all the systems reviewed appeared to be very useful devices, despite these lacks.

EXTENT of USE

Texas Rehabilitation Center apparently applies linkage feeders primarily or solely for use with lapboards. Most of the other institutions plan more extensive use, particularly that involving activities at tables or desks, with a strong bias toward vocational rehabilitation or an approximation of normalcy. This difference in approach obviously influences feeder design and application, particularly with respect to the "reach" provided and provisions for securing adequate trough height to avoid disturbing objects on the table or desk. Total linkage length, the use of drop rather than straight swivel arms, and curved rather than straight distal links, may all be affected by these considerations.

On this question of limited *vs.* extended feeder usage, the latter approach (maximum function and use) seems preferable unless the goals are unrealizable.

LINK LENGTHS AND RATIOS

In mechanical terms, the maximum feeder reach is the sum of the lengths of the proximal and distal links, while the minimum reach is the difference between the two lengths. Kinematically, the two links should be of equal length.

A considerable variety of link lengths and ratios was evident in the five feeders reviewed, each apparently representing a compromise between kinematic and practical considerations, that is, the need to reduce the length of the proximal links to permit passage through doorways without interference by the projecting joint between the proximal and distal link. All compromises apparently worked satisfactorily. However, the maximum length for the proximal link commensurate with noninterference would appear desirable to reduce the stress on bearings.

BEARINGS AND FRICTION

Four of the feeders reviewed incorporated ball bearings to reduce joint friction while only one (Texas Institute for Rehabilitation and Research) used needle bearings. However, since these latter were said to be strong and durable and result in smaller joints, they may well be the bearings of choice.

There was some difference of opinion concerning the need for antifriction bearings at the rocker-arm assembly (for trough function). Some conferees deemed a small amount of friction (for dampening) desirable here (for some patients); others disagreed. An obvious solution to meet both contingencies would be the incorporation of antifriction bearings, with nylon washers available for insertion if friction were desired.

DISTAL LINKS

Straight, angled, and curved distal links were represented in the feeders reviewed. Functionally (reduced interference between distal link and trough) and aesthetically, the curved links appeared to be superior.

TROUGH PIVOTS AND FOREARM POSITION

Despite the variety of rocker-arm assembly designs and trough-pivot positions (offset, below the trough, and forked to each side of the trough), the function of all designs appeared to be reasonably satisfactory. Independent engineering opinion tended to favor a forked pivot supporting the trough halfway through the thickness of the forearm rather than below it.

Forearm motion (sliding) within the trough was considered. The value of the typical elbow disk (dial) in stabilizing the forearm was questioned by the engineering consultants at the workshop. A strap that pivots on an axis passing through the anatomical axis of the elbow (as in the University of Michigan design) was considered to be more satisfactory. Velcro was suggested as a possible means for retaining the forearm in the trough.

COSMESIS

Feeders are rather conspicuous, mechanical, utilitarian devices. Hence the stress placed on cosmetic considerations by the conferees was all the more noteworthy. Two factors are apparently involved: *first,* the appearance of the feeder itself, that is, graceful lines, lack of obtrusiveness, etc.; *second,* the simulation of normalcy in use, for example, sitting at the table to eat a meal rather than using a lapboard.

AN APPROPRIATE NAME

So-called linkage or ball-bearing feeders are obviously more than this name connotes. A less awkward term that would more appropriately define the characteristics and function of the device would be very desirable. Numerous suggestions were made by the conferees, including the term "balanced forearm orthesis" developed by Dr. Robert L. Bennett at the Georgia Warm Springs Foundation. However, none of the suggestions aroused any enthusiasm.

POTENTIAL USERS

An attempt was made by the workshop participants to estimate the number of persons who would derive benefit from the use of a feeder.

It was mentioned that a large but unspecified number of postpoliomyelitis patients would require such devices for the remainder of their lives.

As far as new cases were concerned, the five centers represented at the workshop fitted a total of approximately 150 cases per year. It was estimated that an equal number of patients who might benefit from feeders were not being fitted because of lack of publicity concerning their value or lack of knowledge concerning applications. The conferees were also of the opinion that although new poliomyelitis patients are rare, survivors of automobile, diving, trampoline, and other accidents resulting in high spinal-cord injuries are increasing. In general, these patients require more sophisticated feeders than those developed originally for victims of poliomyelitis.

NEED FOR FURTHER RESEARCH

All the feeders reviewed appeared to be of fairly adequate design, and all appeared to be fairly useful devices. Presumably, each device could be improved by incorporating features in other designs, or by taking cognizance of suggestions advanced during the workshop. However, further research to develop a new design—a "super feeder"—does not seem indicated at the present time.

NEED FOR EDUCATION

If, as postulated at the workshop, numerous patients with high spinal-cord injuries (who could benefit from the use of a feeder) are not being provided with the device, an obvious educational need exists. To meet this need, two elements are involved: *first,* information concerning the existence and usefulness of linkage feeders should be brought to the attention of physicians and institutions treating appropriate patients; *second,* hospital and rehabilitation personnel should be trained in the application and adjustment of the device.

To these ends, it was considered that:

1. Publicity might profitably be given to the NYU review and to the deliberations of the workshop conference.

2. Announcement should be made that commercially made feeders closely resembling the Rancho Los Amigos Hospital model described in the NYU report are available.[3]

3. Announcement should be made that instructional material dealing with the application and adjustment of feeders has been prepared by the Georgia Warm Springs Foundation *{1, 2)* and Rancho Los Amigos

[3] Jaeco Orthopedic Specialties, Box 616 M-R5, Hot Springs, Ark. 71919; J. A. Preston Corp., 71 5th Ave., New York, N.Y.; Orthopaedic Supplies Co., Inc., 9126 East Firestone Blvd., Bldg. R, Downey, Calif.; Rehabilitation Equipment, Inc., 175 E. 83rd St., New York, N. Y. 10028.

Hospital *(4, 5, 6),* and that reports on design principles have been published by the University of Michigan *(7, 8).*

4. Based on available experience, information concerning feeder design principles and applications might well be included in one or more courses offered by the Prosthetics and Orthotics Education Program.

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