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A New Ankle-Foot Orthosis Combining the Advantages of Metal and Plastics

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Jointed Plastic Bracing (JPB), a new orthotic concept in the treatment of lower-limb paralysis or paresis, which combines the attributes of metal and plastic, using the preferred characteristics of both in a single orthosis has been developed.

The necessity of applying a lower-limb orthosis is determined by a number of factors and treated by use of a variety of orthotic designs. For the sake of brevity, this discussion will be limited to those diagnoses concerning the ankle. Historically and typically, problems about the ankle would have been treated by the application of an orthosis constructed of metal and leather. The bulk and weight of such an appliance stimulated a search for a better method. With the advent of thermoplastic materials new designs have been developed. Plastics, however, have not yielded a satisfactory joint, thus limiting mobility of the anatomical joint involved. In order to retain the flexibility of a metal joint, and also retain the light, cosmetic attributes of plastic, a wedding of the materials has been carried out. The union has resulted in a new and versatile approach for lower-limb orthotics. Jointed Plastic Bracing has now been applied to more than 50 patients during the past year with excellent results.

HISTORY

Orthoses, until recent years, used metal joints placed in a position to approximate the anatomical joints. These orthoses generally did permit improvement in mobility of the patient and, thereby, resulted in an increase of his activity level. However, in too many cases, to stabilize meant to immobilize and to mask incomplete correction. The metal orthosis provided a measure of security to the patient, and had a long life due to the types of materials used, and there are still some situations which can best be treated with the application of a metal orthosis. The obvious shortcomings of metal are poor cosmetic appearance and the weight involved, not to mention the difficulties in keeping that type of appliance clean.

The advent of plastics produced a much more acceptable orthosis. Plastics are far more adaptable for conforming to body shapes, and produce an orthosis more acceptable to the eye. Another exciting feature of plastics is the dramatic reduction in weight of an orthosis, since the amount of weight involved in treating a particular diagnosis can be cut from pounds to ounces in many cases. The result of this weight difference was frequently an equally dramatic increase in

the activity level of a patient. Frequently, the control of a paretic or paralyzed limb was considerably more refined by the application of a plastic orthosis. An added advantage realized in this area was the reduction of pressure problems caused by the application of a standard metal orthosis due to incomplete correction. Plastics, furthermore, are readily cleaned with mild soap and water.

Experience with plastics has happily proven that plastic orthoses can readily compete with metal in durability and life expectancy. There are actually fewer repairs due to breakage on a plastic orthosis in comparison to metal orthoses, and the replacement time appears to be about the same. The primary drawback to an orthosis constructed exclusively of plastic is the inability to allow mobility, i.e., joint function. Reduction in the amount of plastic applied around a particular joint is essentially the only means of increasing the mobility of that joint. Many "plastic joints" have been developed, but to date none has been proven adequate when incorporated into an actual orthosis.

METHODOLOGY

The inadequacies of the previously described orthoses led to a design that used "the best of both." The result is an orthosis fabricated primarily of plastic, but uses metal to provide the joint motions needed. In this way, light weight was sacrificed to obtain the desired joint function.

To illustrate the use of the new concept, consider the application of this type of orthosis to the diagnoses concerning the ankle joint. The more frequently encountered forms of paralysis or paresis for the ankle joint are generally categorized into:

1. foot drop—lack or loss of dorsiflexion only
2. lack or loss of plantarflexion
3. pes planus, valgus or varus.

Any or all of these specific problems can be controlled by an orthosis constructed solely of either metal or plastic. Selection of an orthosis that will not only provide the best control, but will also take into consideration individual factors unique to a particular patient will require a close analysis. Consideration in this analysis should include:

1. diagnosis
2. muscle(s) involved
3. patient's age, weight, functional, and activity level
4. cosmesis, and
5. contributing physical factors; for example, other non-functioning extremities.

The goal of this analysis is to determine the exact orthosis for this particular patient, and how to accomplish this goal with the least amount of "bracing" without sacrificing any possible functional gain.

In order to analyze the success or value of a given orthosis, the desired criteria of an orthosis must be examined:

1. improved mobility for increased independence
2. fit and control
3. safety
4. cosmesis
5. life span of the orthosis.

Normally, foot drop alone can be controlled with a posterior leaf ankle-foot orthosis (AFO) of plastic. However, if foot drop is complicated with pes planus, valgus or varus, a custom molded foot piece with medial-lateral ankle joints is beneficial. Either a spring dorsiflexion assist or a limited motion ankle joint with a posterior stop (Fig. 1) may be used here. The combination of a well-molded plastic foot cup, metal ankle joints and plastic calf cuff obtain a good correction, and the anatomical joint is controlled or free to function as desired.

In the instance of lack of plantarflexion, a reverse-spring loaded assist would

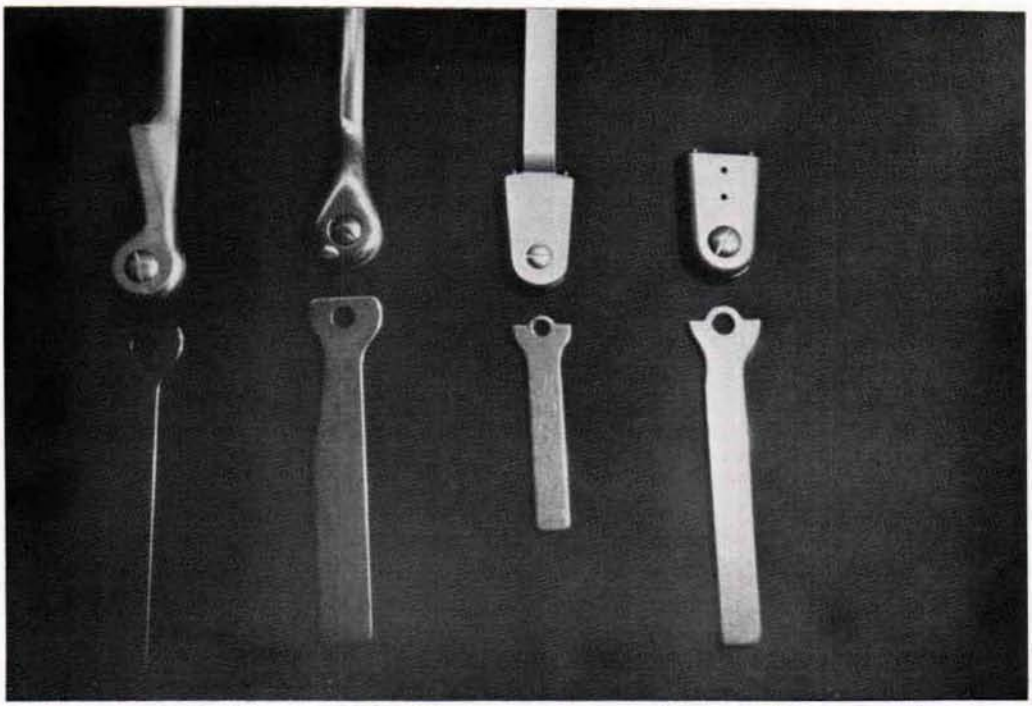

Fig. 1. Types of ankle joints. L to R: Dorsiflexion assist or reverse for plantarflexion assist; limited motion or free motion; bical; and another bical.

Fig. 2. Extension of calf piece.

be required in the ankle joint (Fig. 1). Again, custom molded plastic foot and calf pieces complete the orthosis.

In cases of either medial or lateral instability, an extension of the calf piece is made to come to a point just above the malleolus on the weaker side (Fig. 2).

FABRICATION PROCEDURES

The procedure for fabricating a Jointed Plastic Brace (JPB) combination orthosis is essentially the same as for an all plastic orthosis. A plaster cast is made of the patient's limb in the corrected position; from this is made a plaster model of the limb which is used in the actual fabrication of the orthosis (Figs. 3 and 4). The joints are applied to the plaster model, and positioned correctly before the plastic is drawn over the mold (Fig. 5).

Note that the joints and metal components are lined with ¼-in. thick Plastazote (Fig. 6) before the plastic is drawn

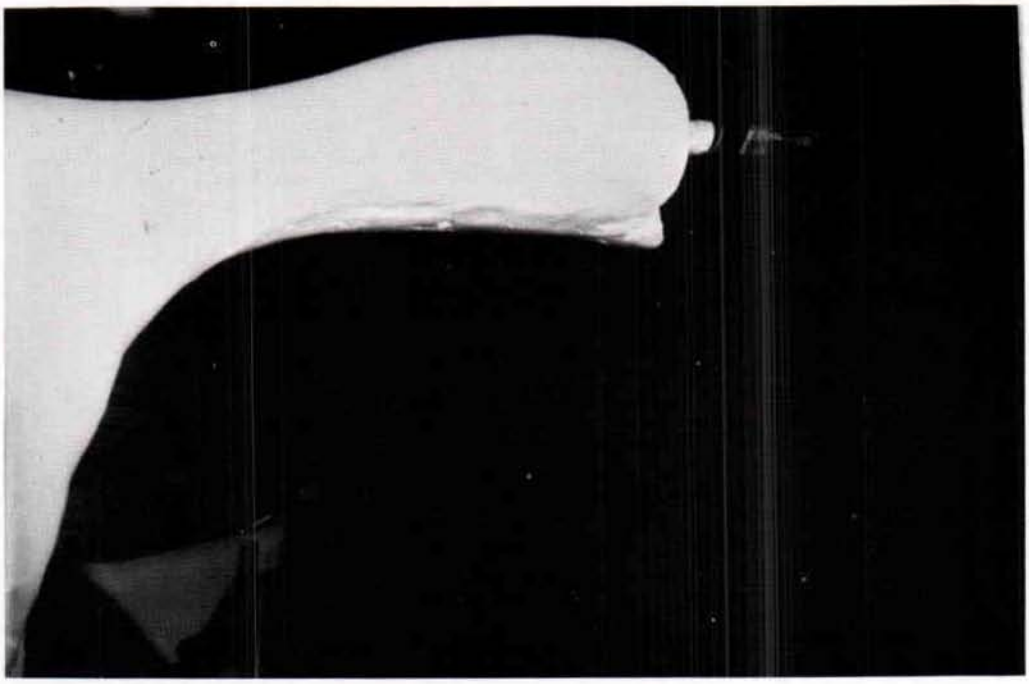

Fig. 3. Plaster model.

over the mold and vacuum applied (Fig. 7).

The application of the joints before forming by vacuum allows for a smooth union of the elements of the orthosis. The trimming of the plastic, and refining of the original product is again essentially the same as for an all-plastic orthosis. Two examples of completed Jointed Plastic Braces are shown in Figure 8.

ACCEPTANCE

To determine the impact of the new combination orthosis, a study was conducted to determine parental reaction to Jointed Plastic Bracing.

Questionnaires were prepared and sent to parents of twenty-seven children who had been fitted with a JPB since November, 1975. The two-page questionnaire consisted of demographic information, forced choice questions, and open ended queries; data on bracing and adjustments

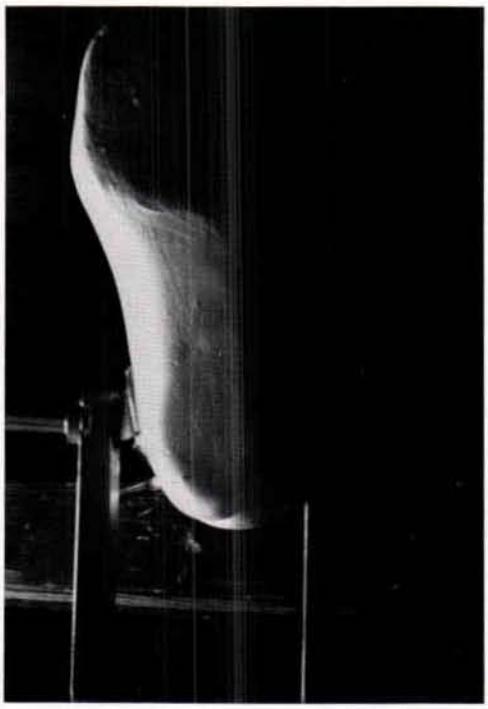

Fig. 4. Corrected alignment.

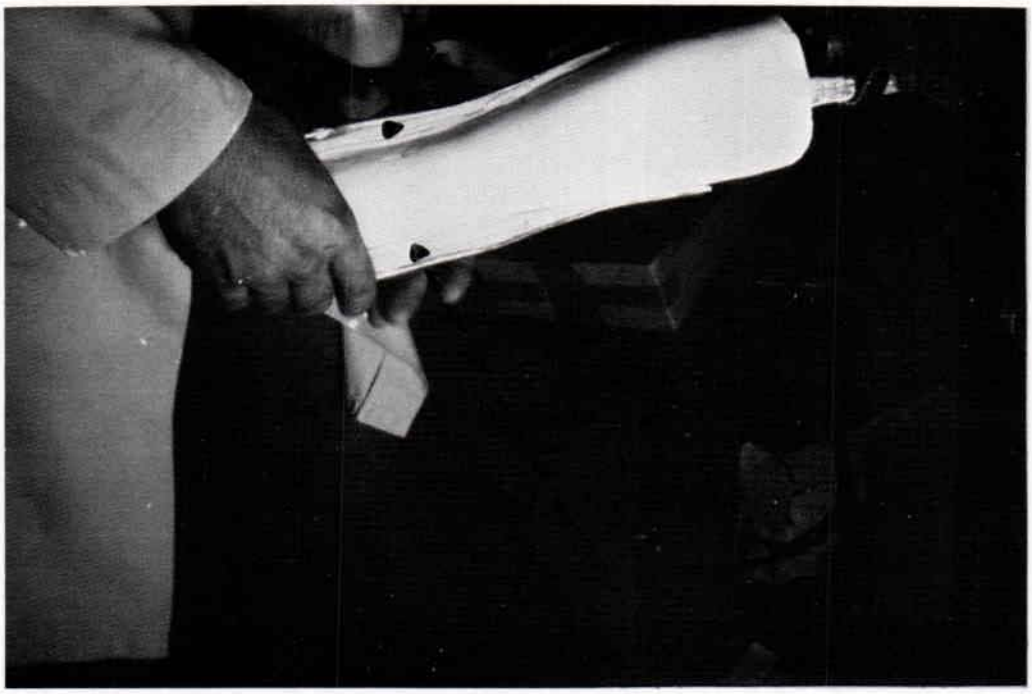

Fig. 5. Application of ankle joints to plaster model of patient's foot and shank.

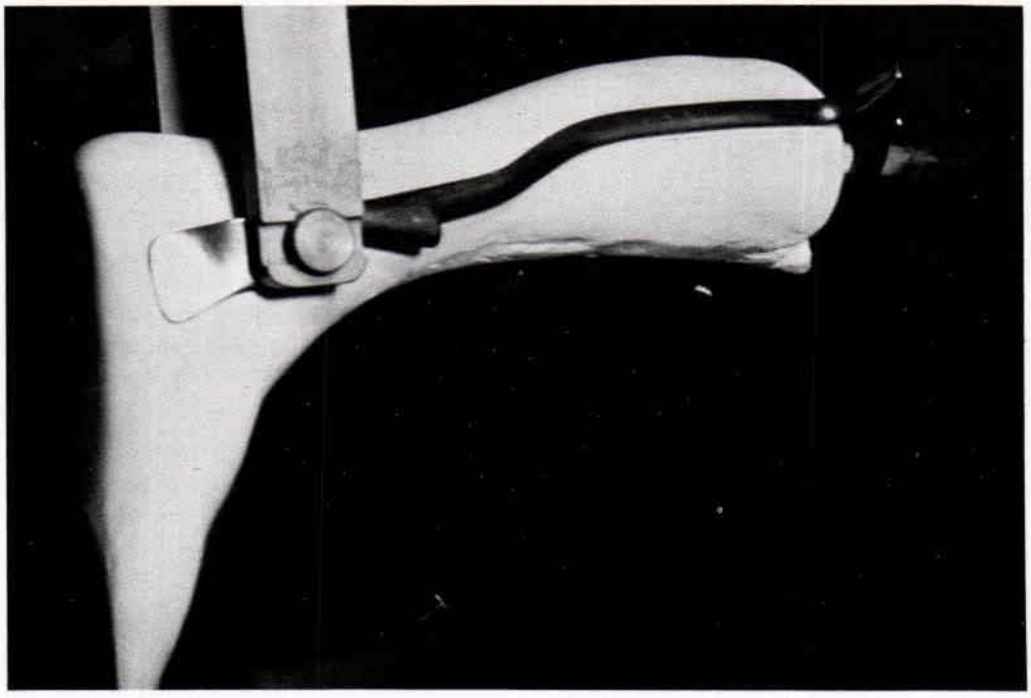

Fig. 6. Plastazote is used to fill space at joint.

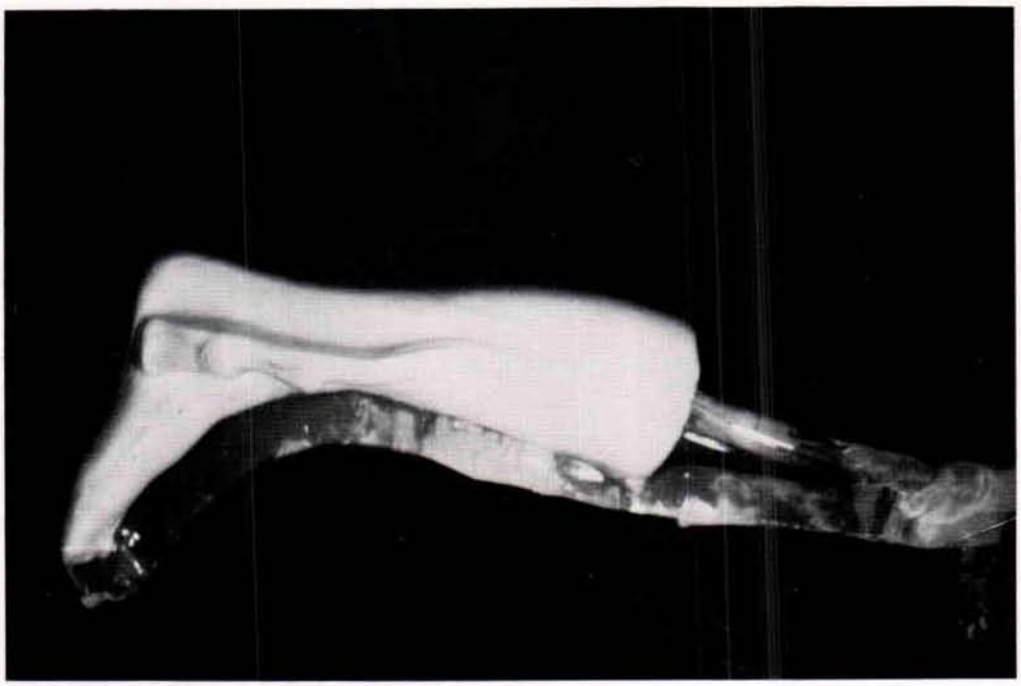

Fig. 7. Vacuum is used to form shape of plastic components.

were also gathered from patient files.

Nineteen completed questionnaires were returned for a 70 percent response rate; those nineteen served as a basis for the following analysis.

Demographically, by sex, the parents responding represented nine girls and ten boys. By age on last birthday the children in JPB in this study, the range spanned age one to thirteen with the average age at 5.94 years, the mean at 5.66 years, and the mode at 4 years.

By diagnosis the greatest percentage of children's handicaps resulted from cerebral palsy; the next greatest resulted from spina bifida (Table 1).

Diagnosis	*Percent*
Cerebral Palsy	37
Spina Bifida	26
Hemiparesis/spastic leg/ foot drop	21
No answer	16

Table 1.

Over half of the children had been fitted with bilateral Jointed Plastic Braces (58 percent). Three children wore Jointed Plastic Braces on their right lower limbs and five on the left only.

When parents were asked to compare Jointed Plastic Bracing to previous bracing, an overwhelming response was received preferring JPB over other bracing. Eighty-nine percent of the respondents felt JPB to be the best; one respondent only thought the previous braces to be better. On a comparison basis, 63 percent of the respondents perceive the JPB to be somewhat better to much better than previous bracing.

In terms of gait evaluation and in evaluating the child's walking with the Jointed Plastic Braces, 89 percent of the parents rated it fair or above. By comparison, in evaluating the child's walking without the JPB found 84 percent of the respondents listing it fair to very poor. An evaluation of rating the child's walking

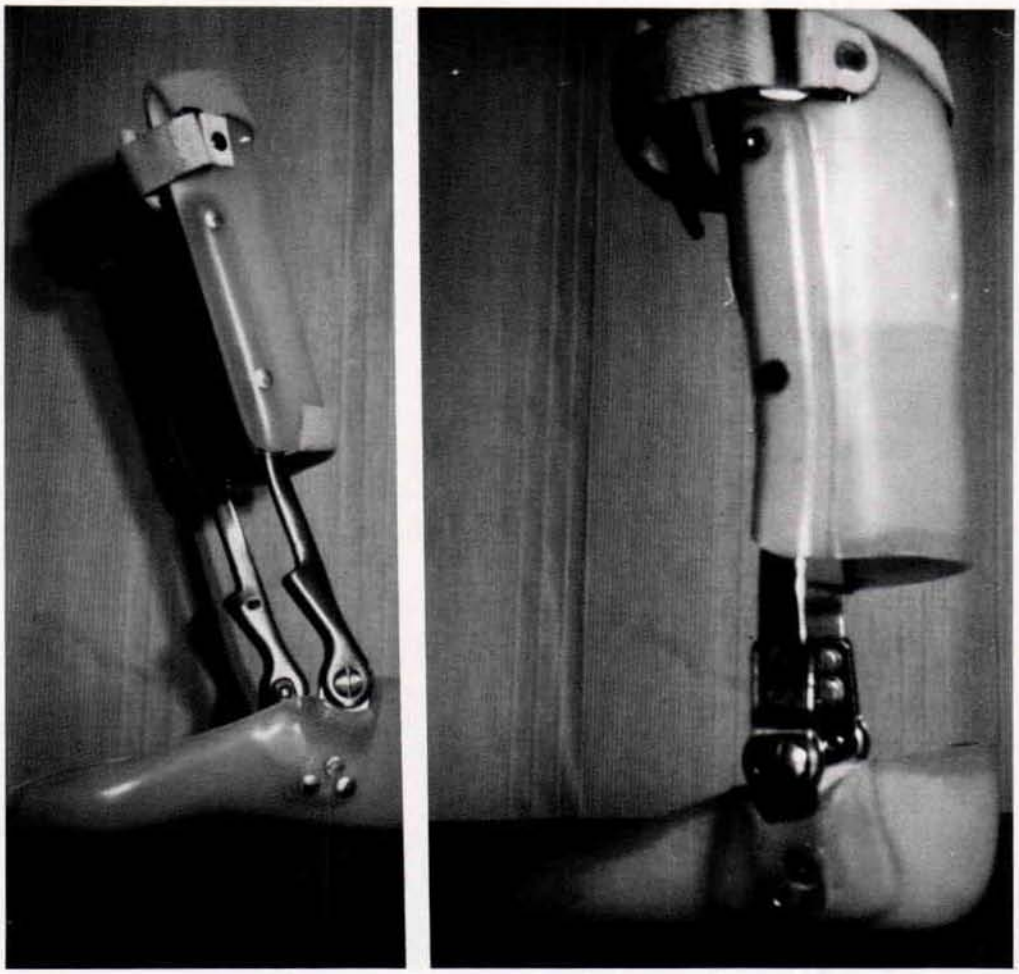

Fig. 8. Two views of the completed jointed plastic orthosis that uses dorsiflexion assist ankle joints.

with previous bracing produced a 74 percent fair or above ranking. In conclusion in rating gait, 89 percent of the parents gave the best appraisal to the child's walking with the Jointed Plastic Braces.

The parents were also given a listing of potential problem areas encountered with Jointed Plastic Braces by frequency of occurrence. The results are presented in Table 2.

Pressure areas	*Frequently*	*Occasionally*	*Never*
	Frequency of Occurrence		
Problem	*Frequently*	*Occasionally*	*Never*
Pressure areas	4	12	2
Breakage	1	5	11
Adjustments	4	11	1
Fit with shoes	—	9	6
Clothing	2	2	12
Other	—	1	—
Totals	11	40	32

Table 2.

It appears that the most problems occurred with excessive pressure and with adjustments; however, both of these problems occurred occasionally rather than frequently. Actually, the respondents do not perceive as many problem areas nor as frequently as had been anticipated.

Two open-ended questions related to advantages and disadvantages of Jointed Plastic Bracing were also provided. The advantages listed here were reported by at least three parents and are presented in order by most frequent mention:

1. more natural means of balance/walking
2. lighter
3. wear with any shoe
4. stronger
5. more cosmetic

The disadvantages using the same criteria of inclusion are:

1. shoe damage/shoe fit
2. cost
3. heavier
4. stiff joints/oiling required
5. need for precise fit

CONCLUSION

This orthotic concept does not replace either plastic or metal, but combines the two, thereby offering another alternative for treatment when an orthosis is required. If, by applying this analysis, a combination orthosis is utilized, it clearly meets the criteria established for a satisfactory orthotic result. Parental evaluation and perception of Jointed Plastic Bracing found it to be a much better alternative to previous types of bracing for their children.

SUMMARY

A new orthotic concept in the treatment of lower extremity paralysis or paresis which combines the attributes of metal and plastic, using the preferred characteristics of both in a single orthosis has been implemented. In order to retain the flexibility of a metal joint and also retain the light, cosmetic attributes of plastic, a wedding of the two materials has been effected. By combining the use of a well-molded plastic foot cup, metal ankle joints, and a plastic calf cuff, a good correction is obtained and the anatomical joint is controlled or free to function as desired. This has resulted in a new, more versatile concept for lower-limb orthotics. Jointed Plastic Bracing (JPB) has been applied to more than 50 patients during the past year with excellent results. Indications, specifics of construction, clinical application, and results in some of these fifty (50) patients has been discussed.

Footnotes

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