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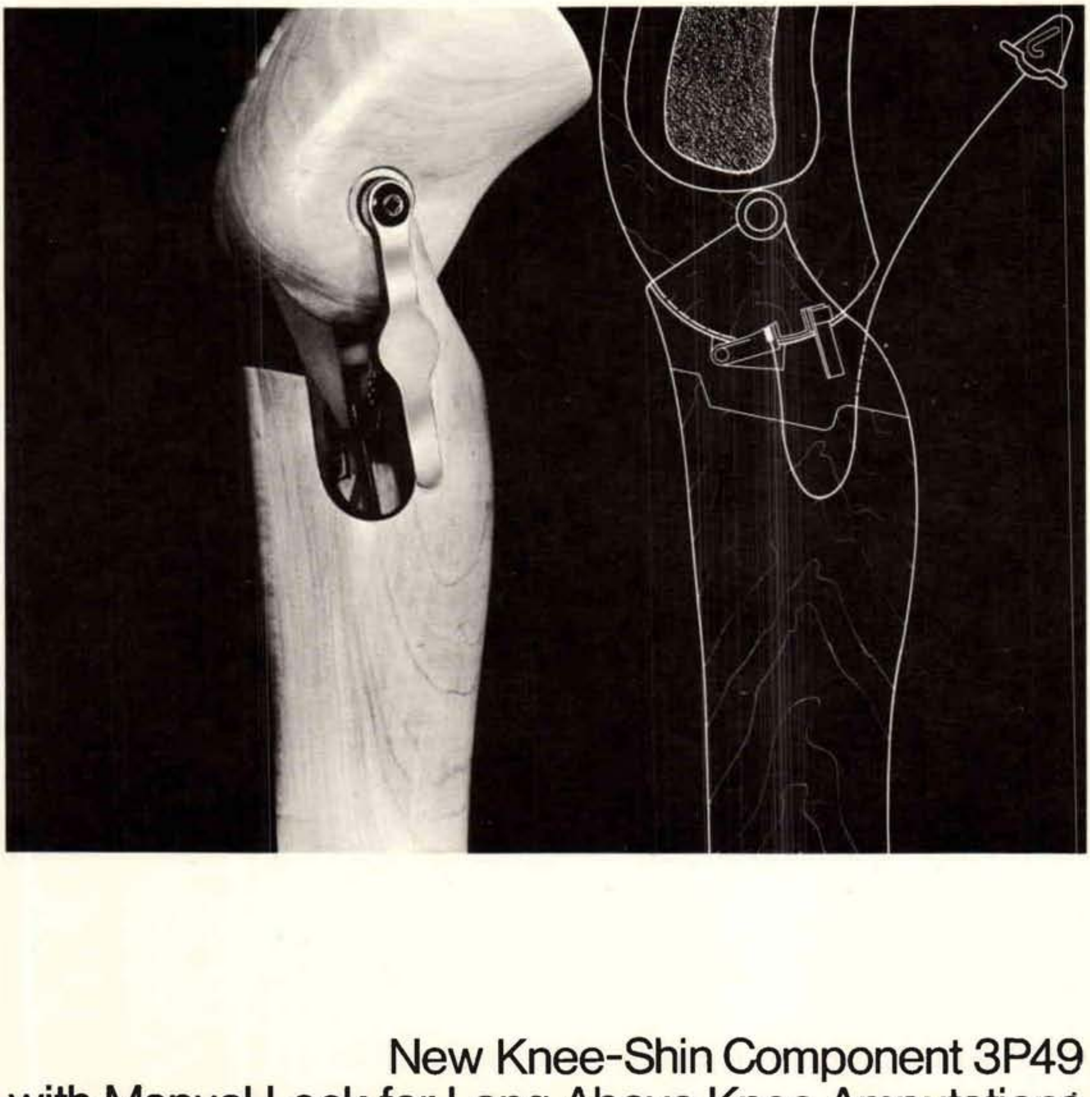

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CONTENTS

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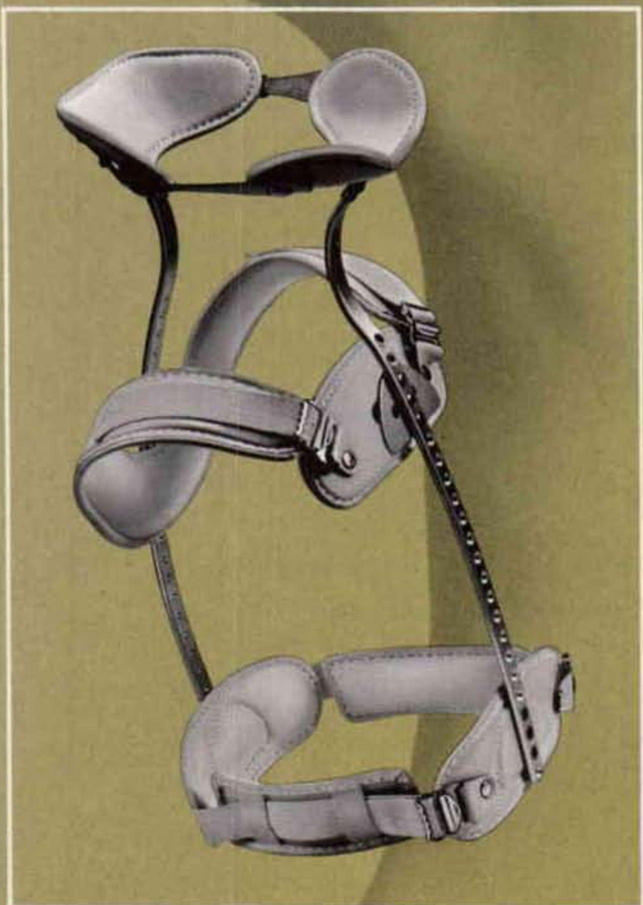

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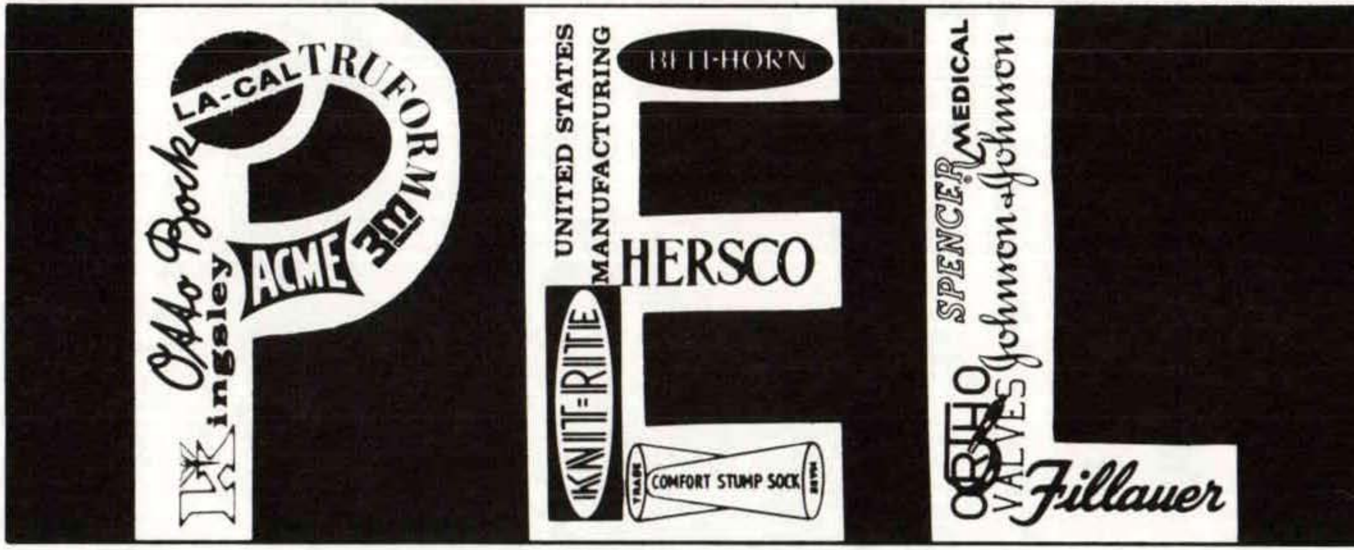

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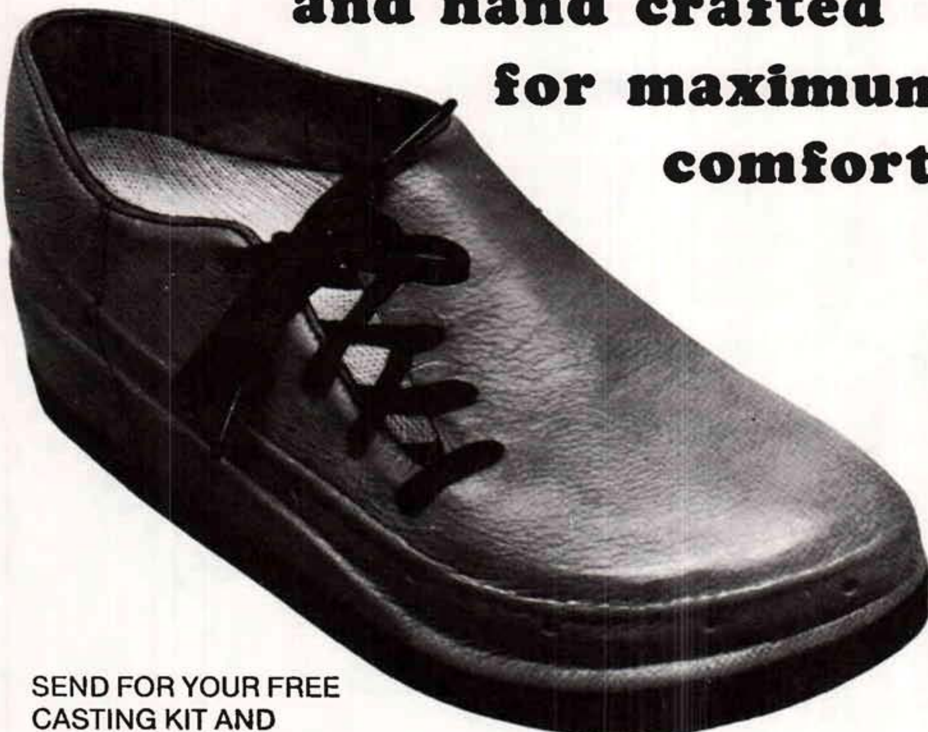

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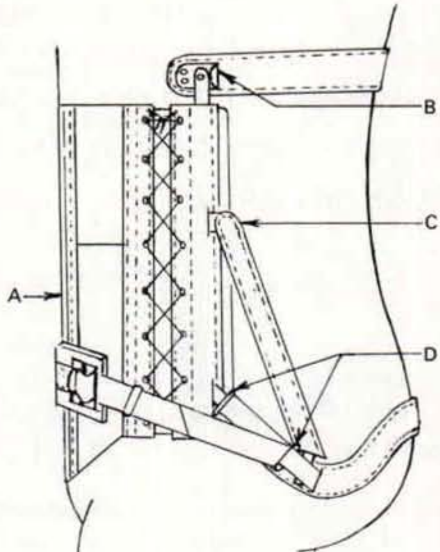

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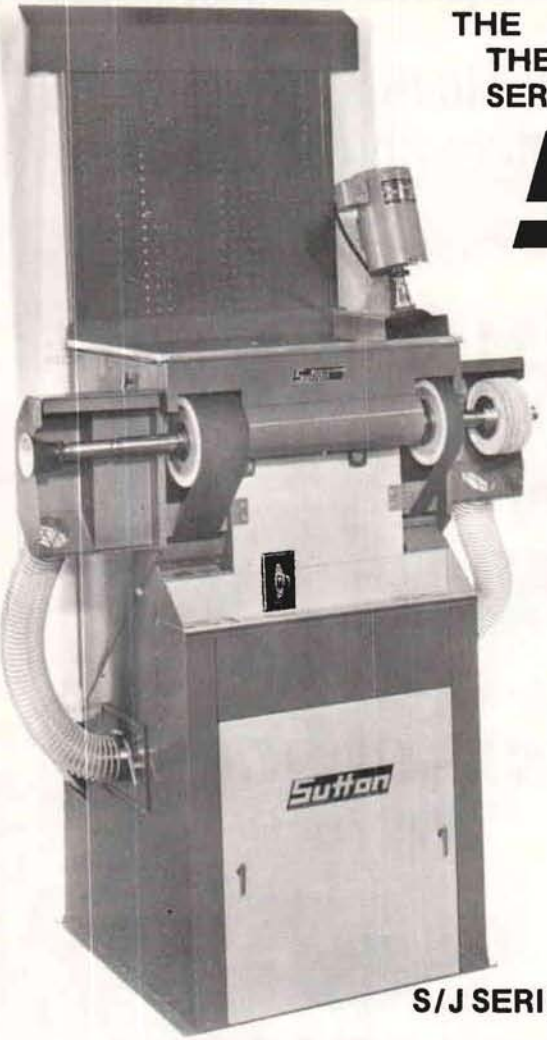

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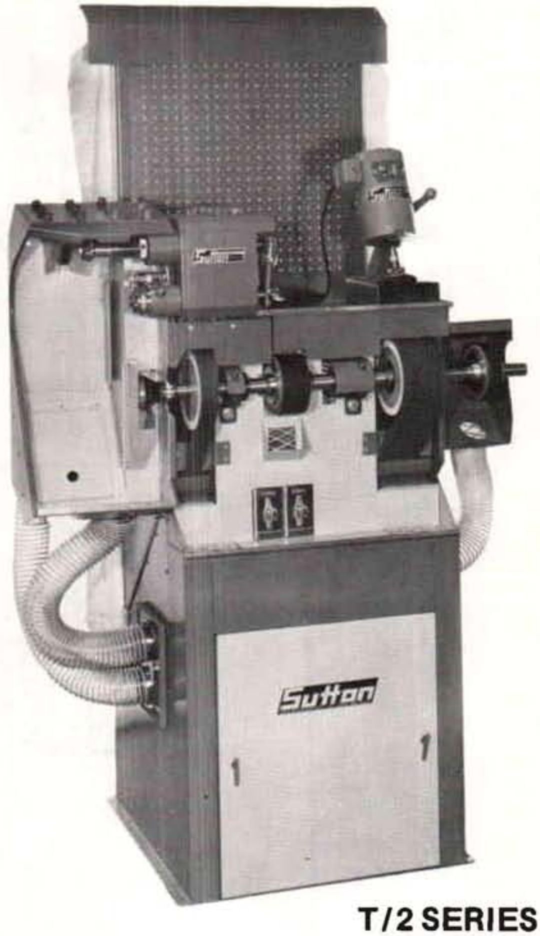

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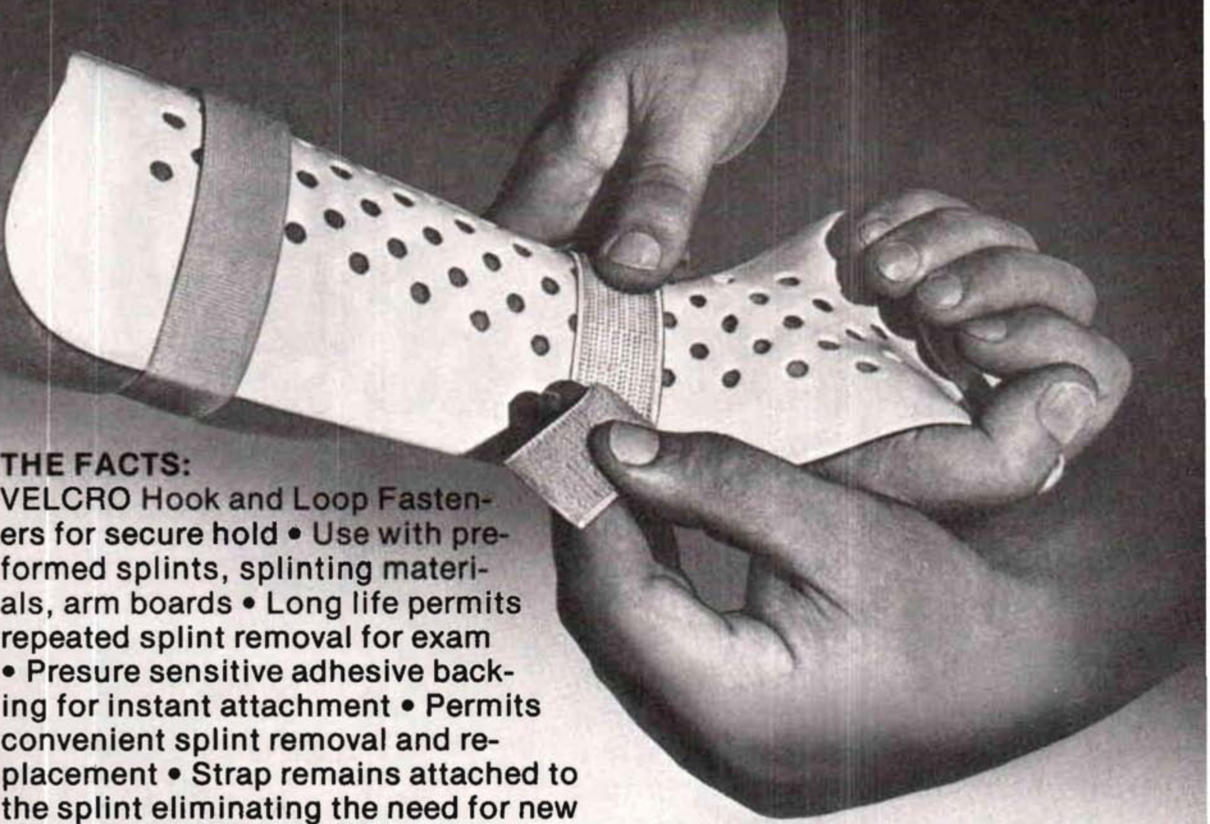

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An Assessment

ORTHOTICS AND PROSTHETICS became a quarterly publication beginning with the March 1949 issue, when it was called the "OALMA (Orthopedic Appliance and Limb Manufacturer's Association) Journal." Until December 1971, OALMA and AOPA had the sole responsibility for the "Journal." Beginning with that issue, the responsibility for editorial content was turned over to AAOP, and A. Bennett Wilson, jr., was appointed editor. He was especially qualified after years as Executive Director of the Committee on Prosthetic Research and Development of the National Academy of Sciences, and as Editor of their publication, "Artificial Limbs." Since that time nearly all of the articles have been prepared especially for clinicians. In March 1973, the size and appearance of the Journal was changed to its present format.

The Journal is probably the most permanent endeavor of our association. It is the sounding board of our profession. It gives every individual who is interested in prosthetics and orthotics an opportunity to give and to receive—to keep up with trends in our profession. The Journal is dedicated to publishing scientific and technical articles. It exists only for and by the efforts and interest of writers and readers.

It is unfortunate that most of us find it difficult to write a scientific article or case report. Personally, I am only too aware of how difficult it is for me. If you have an idea and want to write about it, remember there are individuals on our National Office staff and the editors who are ready to help.

On the positive side, however, there have been many in our field who have contributed by making that extra effort to write and pass on to others their special knowledge.

We thought it would be of interest to look back and determine what was being published and who has been doing the writing during the past 15 years. We separated the articles into three categories—Prosthetics, Orthotics, and Other (i.e., university progress reports, rehabilitation philosophy, education, ethics, etc.). There was a total of 398. Distribution was as follows:

	Prosthetics	*Orthotics*	*Other*
15-year total	146	142	110
	37%	36%	17%

The even split between prosthetics and orthotics was surprising, prompting us to break the figures down into five-year periods, with the idea that some trends might be determined:

	Prosthetics	*Orthotics*	*Other*
1963-67 (148)	59	42	47
	40%	28%	32%
1968-72 (97)	30	38	29
	31%	39%	30%
1973-78 (153)	57	62	34
	37%	41%	22%

It is interesting to note that in 1963-67 prosthetics was in the lead. Since then the number of articles on orthotics has been increasing. We could say that our Journal is becoming more scientific and technical as shown by the reduction in the "other" category.

We divided the authors into three categories — Prosthetics and/or Orthotists, Physicians and Engineers, and Therapists and others. There were 585 names listed as authors and co-authors. The name of each author who wrote more than one article was included for each article.

	P&O	*Phys/Eng*	*Ther/Other*
15-year total	299	150	136
585	51%	16%	23%
1963-67 182	86	59	37
	47%	33%	20%
1968-72 146	73	36	37
	50%	25%	25%
1973-78 257	140	55	62
	55%	21%	24%

It is especially encouraging to see that the percentage of prosthetists and orthotists who write is increasing. Of this group, seven have written five or more articles. Michael Quigley and Maurice LeBlanc—8, William Tosberg —7, Roy Snelson and John Glancy—6, Richard Lehneis and Melvin Stills—5. These and all the others deserve our appreciation for their efforts.

No drastic changes in the Journal are planned but the Editorial Board and the editor always welcome suggestions for improvement. A special issue to be dedicated to reports from our educational institutions is in preparation. According to the trends, we need more articles in prosthetics to maintain a balance between orthotics and prosthetics.

It has been my privilege to be Chairman of the Editorial Board for the past six years. The work of the Board has been minimized by the interest and cooperation of the editor, members of the Board, members of the National Office Staff, and officers of AAOP and AOPA.

Our new Chairman will no doubt receive this same cooperation and our Journal will continue to be a sounding board for our profession.

Alvin Miulenburg

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Orthotics and Prosthetics, Vol. 32, No. 4, PP. 3-10, December 1978

New Concepts in the Corrective Bracing of Scoliosis, Kyphosis, and Lordosis

ISIDORE ZAMOSKY, C.P.O.[1]

The basic concept of restoring the vertebral column to a perpendicular and symetrical attitude to the pelvis, as a result of forces applied to the column and ribs is appreciated in the following report.

A departure from the "Milwaukee" orthosis has been sought and tried in a number of designs for the treatment of spinal curvatures in the last few years.

The use of a modified body-jacket type of device, hereafter referred to as a "Low Profile", scoliosis, kyphosis, or lordosis corrective orthosis, has been successful in the treatment of 350 patients to date. Most of these were patients with scoliosis, some with associated lordosis and some with kyphosis and associated lordosis. Physicians affiliated with University Hospital, the Hospital for Special Surgery, and the Albert Einstein Institute have used this design. The New York Orthopedic Hospital, Columbia-Presbyterian Medical Center has adopted this design and called it "The New York Orthopedic Hospital Orthosis".

The "Low-Profile" orthosis is presently made of polyethylene, 1/4-inch thick, low density, and stress relieved. The orthosis covers the thorax and pelvis with an anterior opening.

Trim lines, anteriorly from xiphoid process to bilateral, anterior-lateral corn-

Fig. 1. Anterior view of the Low-Profile Spinal Orthosis.

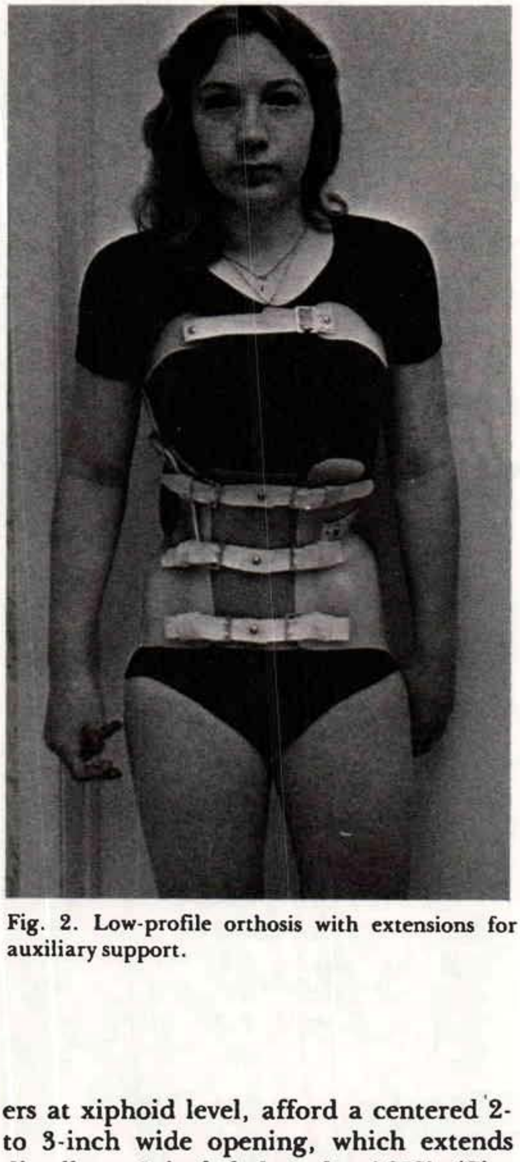

Fig. 2. Low-profile orthosis with extensions for auxiliary support.

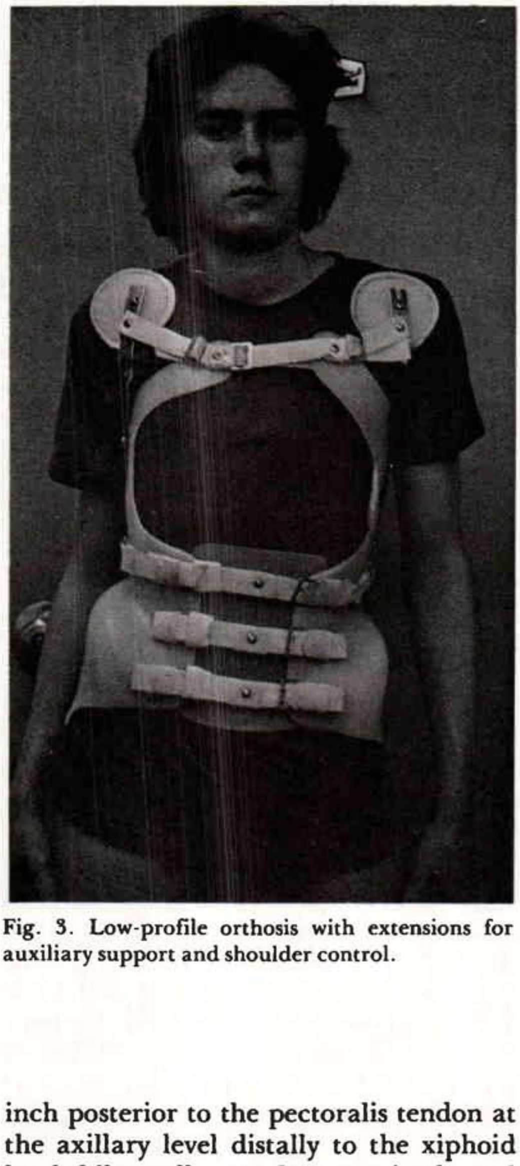

Fig. 3. Low-profile orthosis with extensions for auxiliary support and shoulder control.

ers at xiphoid level, afford a centered 2- to 3-inch wide opening, which extends distally to 1 inch below the ASIS's (Fig. 1).

A tongue of the same material is sandwiched and strapped between the opening and the body, and is overlapped by the edges of the opening.

Thoracic, kyphotic curves or treating generally large patients need extensions for axillary supports bilaterally which are joined by a strap (Figs. 2, 3).

Trim lines extend laterally from 1/2-inch posterior to the pectoralis tendon at the axillary level distally to the xiphoid level bilaterally at the anterior-lateral corners. This purchase of thorax prevents contra-lateral bending above levels of the apices of lumbar or thoraco-lumbar curves. It also affords thoracic level support or force to stabilize or reduce compensatory or flexible thoracic curves. From the ASIS level bilaterally it continues to the distal part of the greater trochanter, gradually to 3/4 inches short of the crest-to-seat measurement at the

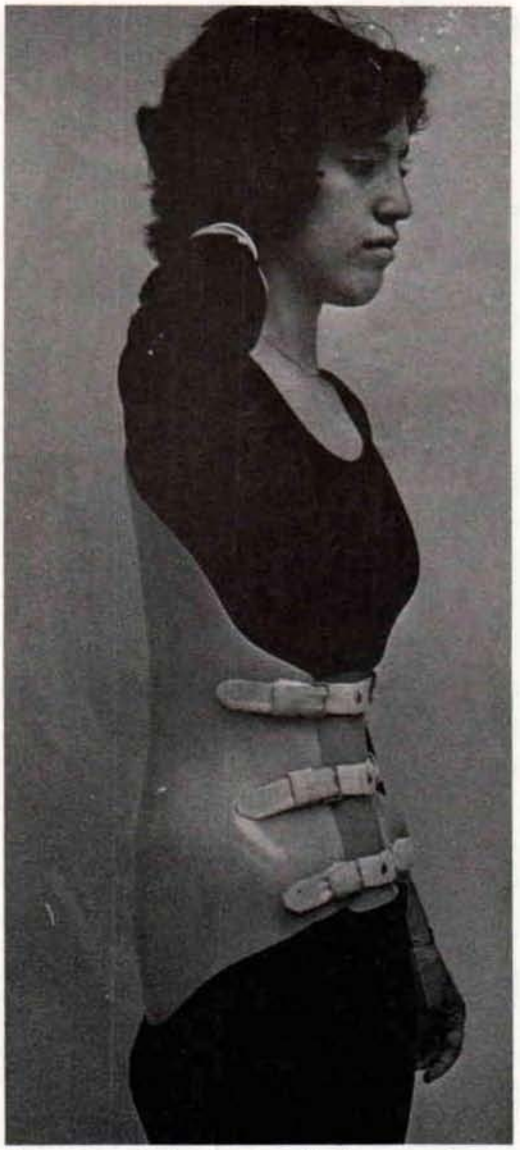

Fig. 4. Lateral view showing trimlines.

Fig. 5. Lateral view of convex side showing trimlines.

gluteus maximus posterior-laterally (Figs. 4, 5, 6, 7).

Trim lines extend posteriorly from 1 inch distal to spines of scapulae (Fig. 8), to 3/4 inch short of crest-to-seat measurement at the gluteus maximus. The attitude of the orthosis implies flexion of the pelvis, flattening of the abdomen, and firm contact at the proximal posterior areas (Fig. 4).

Pads and accessories are shaped and placed over the bodies of vertebrae at and immediately above the apices, down to and including the distal end vertebrae of a curve. The lateral extension to the anterior-lateral corner becomes a long lever arm to affect derotation and subsequent curve reduction. If thoracic lordosis is present, forces should be placed more laterally. However, since ribs are

Fig. 6. Lateral view of concave side showing trimlines.

Fig. 7. Lateral view showing trimlines.

flexible extreme forces can cause deformities of the ribs, so care must be taken. Increasing thoracic lordosis can compromise respiration.

The vertical lengths of pads are determined by the distance between the area immediately above the apicle and below the distal vertebra of the curve. (Fig. 9).

The horizontal lengths are determined by the distance from a point 1/2 inch lateral of spinous processes to the anterior-lateral corners of the torso for either thoracic or lumbar curve levels, (Figs. 5, 6, 10).

The proximal edges of the thoracic or thoraco-lumbar pads are determined by the proximally involved apicle ribs so that

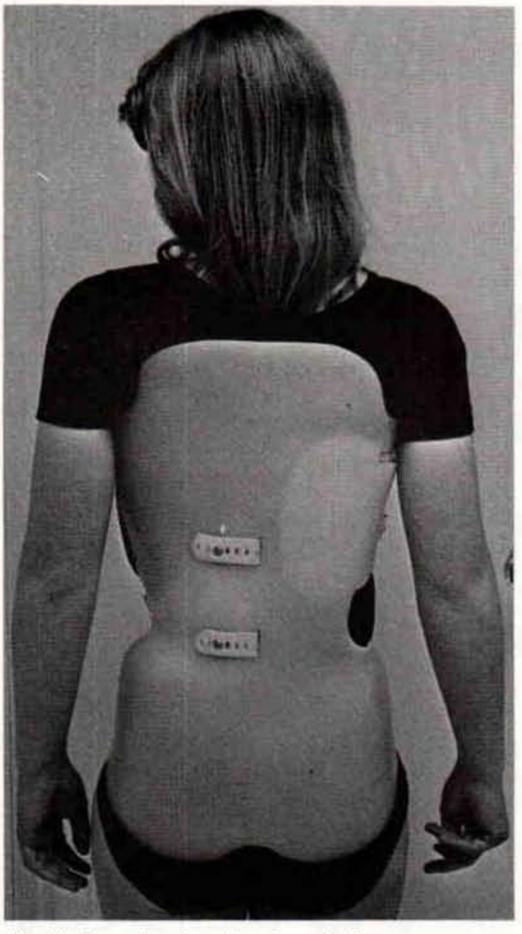

Fig. 8. Posterior view showing trimlines.

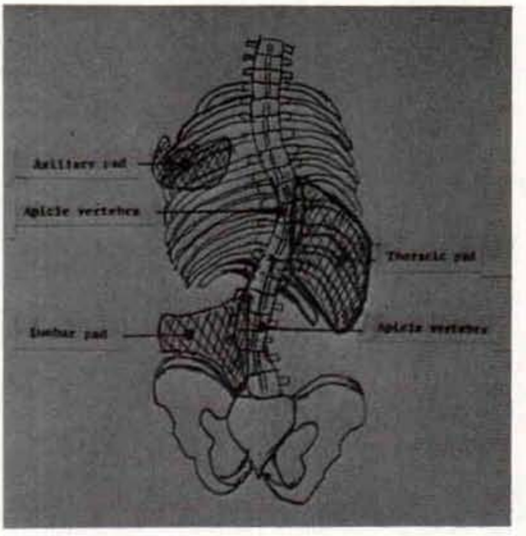

Fig. 9. The vertical lengths of pads are determined by the distance between the area immediately above the apicle and below the distal vertebra of the curve.

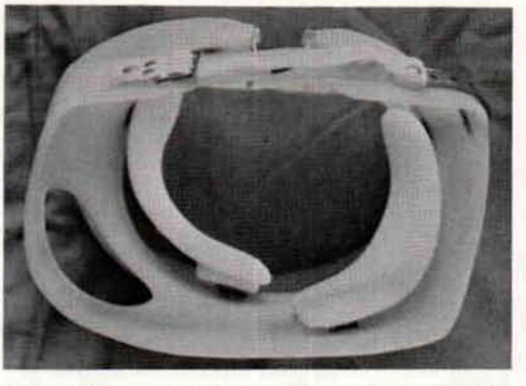

Fig. 10. The horizontal lengths are determined by the distance from a point ½" lateral of the spinous processes to the anterior-lateral corners of the torso for either thoracic or lumbar curve levels. See also Figures 5 and 6.

the verticle and horizontal sides are connected by a concave sloping side, since rib shape tapers. The concave sloping side extends over the involved apicle rib, continuing to the most distal rib involved, (Figs. 9, 11).

Axillary support by padding or trim line extension of the basic orthosis is added to offer support and/or pressure on the involved ribs of the compensatory curve. This is used with double layer, thoracic and thoraco-lumbar curves (Fig. 9).

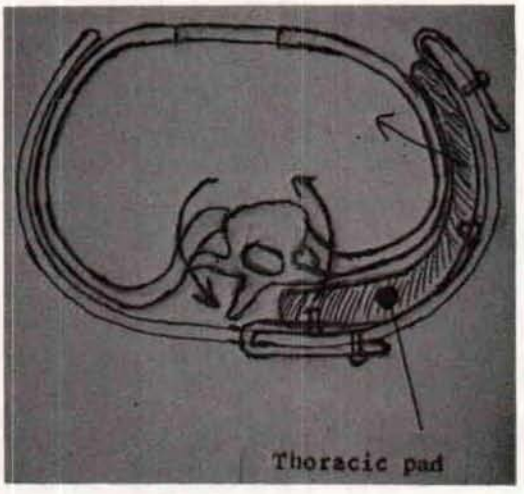

Fig. 11. Horizontal section through the thorax showing forces to achieve curve reduction and derotation. See also Figure 9.

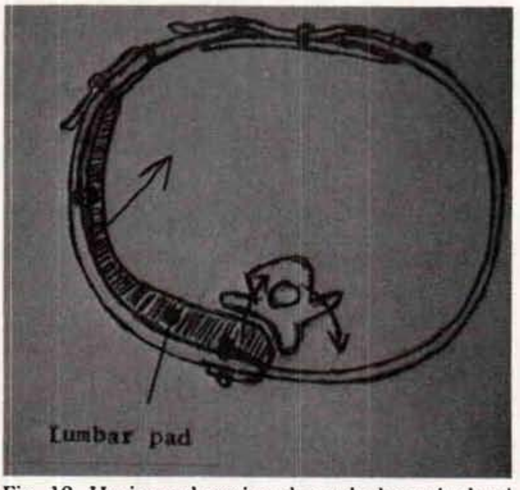

Fig. 12. Horizontal section through the waist level showing forces to achieve curve reduction and derotation. See also Figures 5, 9, and 10.

Lumbar pads cover all soft tissue posteriorly, including bodies of vertebrae 1/2 inch lateral of spinous processes, and laterally to a level in line with the anterior-lateral edge of the axilla line. The purchase of soft tissue in lieu of ribs tends to extend lever arm forces and also helps reduce unit pressure applied to skin (Figs. 5, 9, 10, 12).

Kyphosis pads afford adjustable posterior contact bilaterally from an area end vertebrae involved in the curve. They are placed 1/2 inch lateral of the spinous processes bilaterally to apply anteriorly directed forces on vertebral bodies (Figs. 13, 14).

Shoulder retractor pads are placed anteriorly and apply posteriorly directed opposing forces in the form of bilateral cup shaped pads which contact the heads of humeri. The humeral pads are attached to pivoted bars. The pivots are placed 1/3 to 1/2 the distance from humeral pads to the distal ends of the bars for mechanical advantage. The pivots are mounted on the lateral sides. The distal ends include pivoted loops through which straps are threaded and tightened to buckles or studs mounted anteriorly. Each humeral pad can then be individually adjusted (Figs. 7, 13, 15, 16).

In kyphosis treatment the posterior proximal trim line is carried to mid-scapula level to allow optimal retraction of the shoulders.

Generally the anterior opening design affords a strong posterior and lateral wall combination. Posterior and lateral walls provide necessary room for the migration of tissue involved in curvatures, to the opposite side as well as posteriorly, due to the derotational forces of the pads. Openings are made opposite pads to accomodate the migration of tissue (Fig. 17).

Thickness of pads develops a triangular shaped void of space initially. Viewing

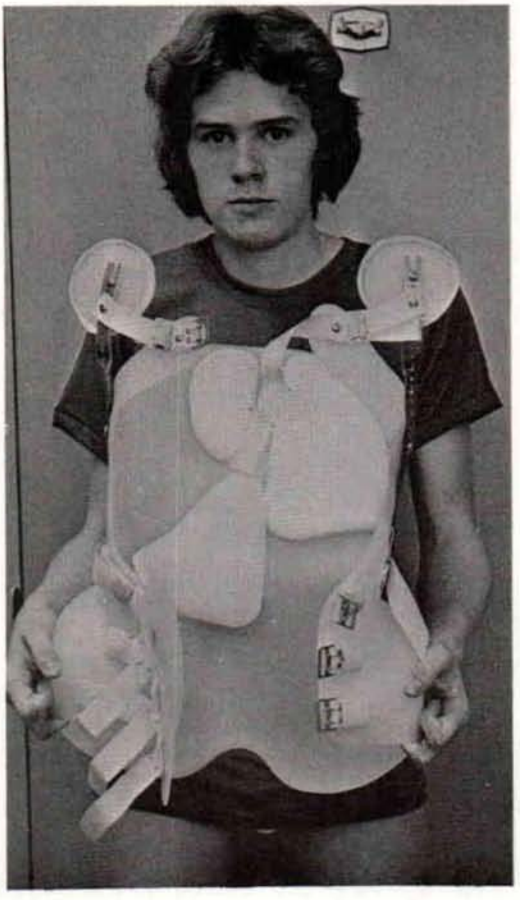

Fig. 13. Anterior view of orthosis to show location of pads.

from the proximal edge into the orthosis, as the patient flexes at shoulder level, this void is apparent. As wearing the orthosis progresses and correction occurs, viewing as above will reveal reduction or elimination of this void of space depending on the degree of correction achieved, (Figs. 11, 12).

The thickness of pads are increased along with strap tightening as curves reduce and bilateral contact occurs at the posterior wall. This pressure can be accomplished by adding material to the pads or heating and depressing the posterior wall in an anterior direction exactly behind the pads, (Figs. 11, 12).

Lordosis associated with scoliosis and kyphosis or lordosis by itself, has been successfully treated by the forces available in the "Low Profile" orthosis. The attitude of the orthosis as earlier discussed, indicates the necessary three point pressure system for correction of lordosis, (Fig. 4).

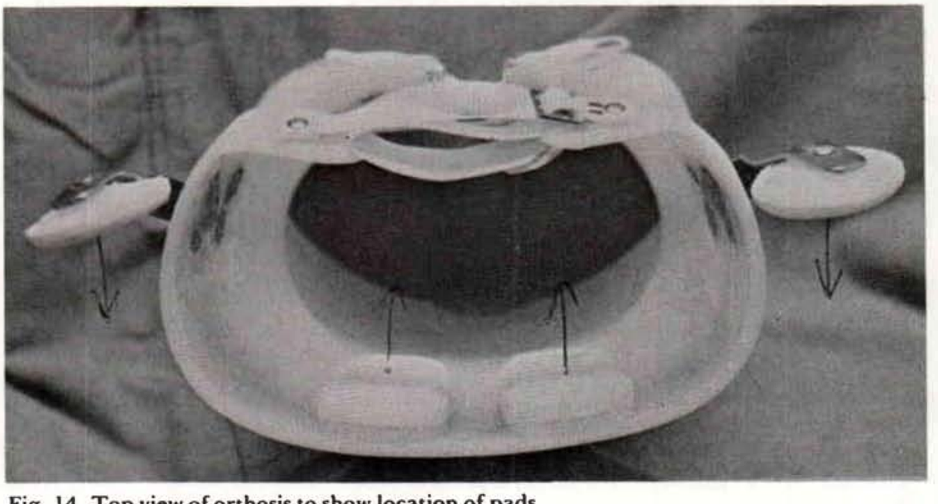

Fig. 14. Top view of orthosis to show location of pads.

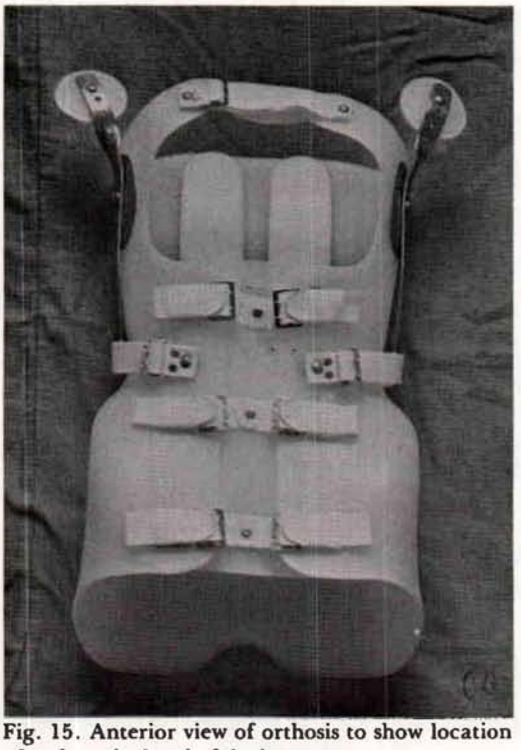

Fig. 15. Anterior view of orthosis to show location of pads at the head of the humerus.

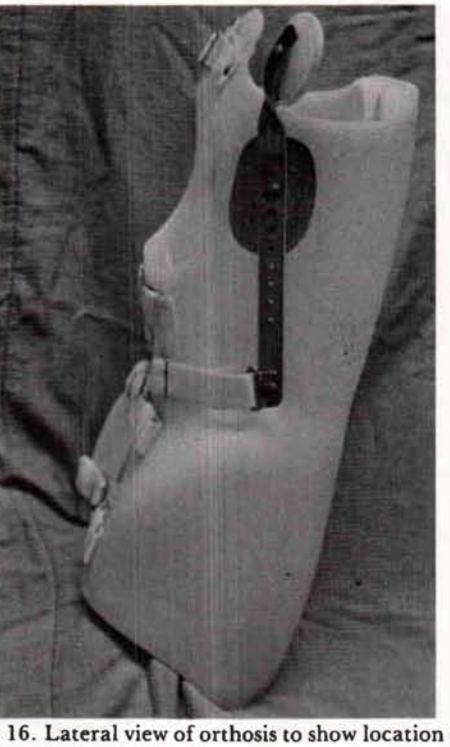

Fig. 16. Lateral view of orthosis to show location of pads at the head of the humerus.

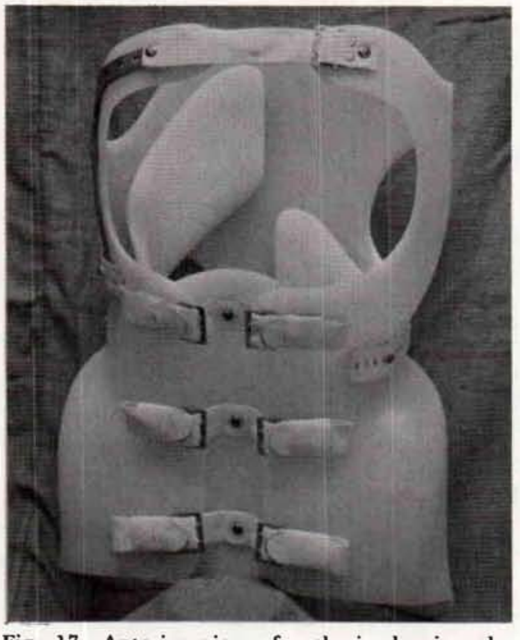

Fig. 17. Anterior view of orthosis showing the openings that are made opposite pads to accommodate for the migration of tissue.

Acknowledgement

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I wish to thank my son, Gary Zamosky, without whose capacity to follow through and develop fabrication techniques in the making of the orthosis, the success of my concept would not have come about.

Footnotes

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Orthotic Management of High Thoracic - Low Cervical Fractures[1]

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ALAN DRALLE, C.P.O.[3]
JUSTUS LEHMANN, M.D.[4]

In stabilizing high thoracic - low cervical fractures, a halo orthosis is safe and effective. It provides maximum stabilization of the fracture site. The University of Washington, Division of Prosthetics-Orthotics, has developed an orthosis which, while it does not provide the rigid immobilization of the halo, does provide adequate stabilization for a fracture which has formed callus, approximately 4-6 weeks postoperative. Clinical experience has shown several worthwhile advantages of this orthosis over the halo, which warrants its use at this stage of the treatment program. The orthosis is a bivalved, laminated body jacket to which a S.O.M.I.[5] superstructure is attached (Fig. 1).

The advantages of this orthosis are: 1) it can be easily and safely donned and doffed, which allows easier hygienic care and allows periodic checks of soft tissue condition; 2) it is light in weight; and 3) the patient is less encumbered than in a halo.

FABRICATION

The patient is casted with a circumferential wrap from symphysis pubis to sternal notch. A fracture table (Fig. 2) is recommended to achieve flexion or extension of the spine which varies with the type of fracture.

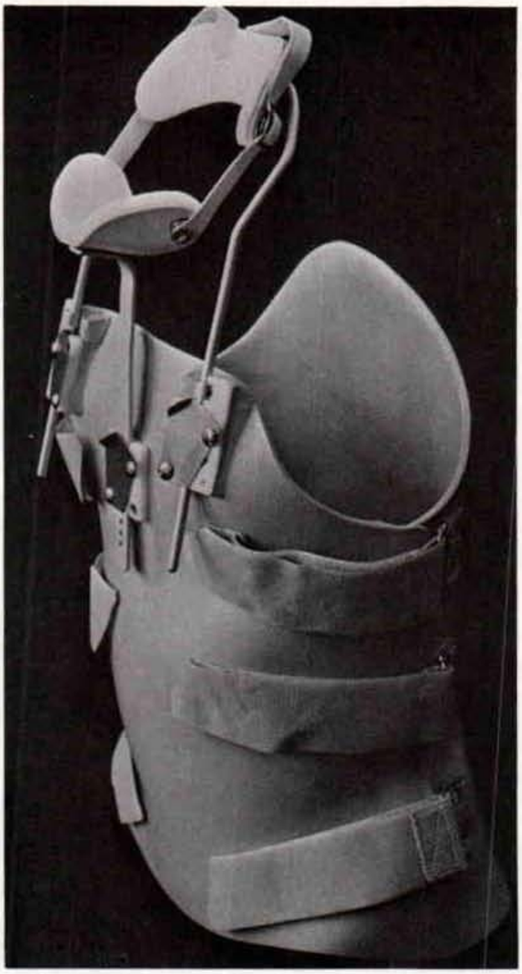

Fig. 1. Anterior-lateral view of the plastic laminated body jacket with S.O.M.I. superstructure.

On the positive mold several modifications are made. Suspension of the orthosis is achieved by removing plaster just proximal to the iliac crests and below the 12th ribs. Slight relief must be made for the spinous processes by building up the plaster positive over the entire length of the spine. In the same manner, relief must be made over the iliac crests and over any protrusions of internal fixation appliances which might be present.

To provide a soft liner, Plastazote is heated and molded to the posterior section of the positive mold, extending anteriorly to the sagittal midline to provide an overlap with the anterior shell.

An inner PVA bag is pulled over the entire mold, followed by five layers of nylon stockinet and an outer PVA bag. Type 4110 resin is used in the laminating process.

The posterior section is trimmed out, and all corners and edges are rounded and smoothed leaving trimlines 1-1/2 in. anterior to the midline.

The posterior section is re-applied to the positive mold. Heated Plastazote is applied to the anterior aspect of the mold, overlapping the posterior section.

The posterior section is laid up and laminated.

The anterior section is trimmed out to just below the sternal notch superiorly and 1-1/2 in. above the symphysis pubis inferiorly. The lateral trim lines allow for a 2 in. overlap on the posterior shell.

The body jacket is trimmed in the axillary area to allow for full range of

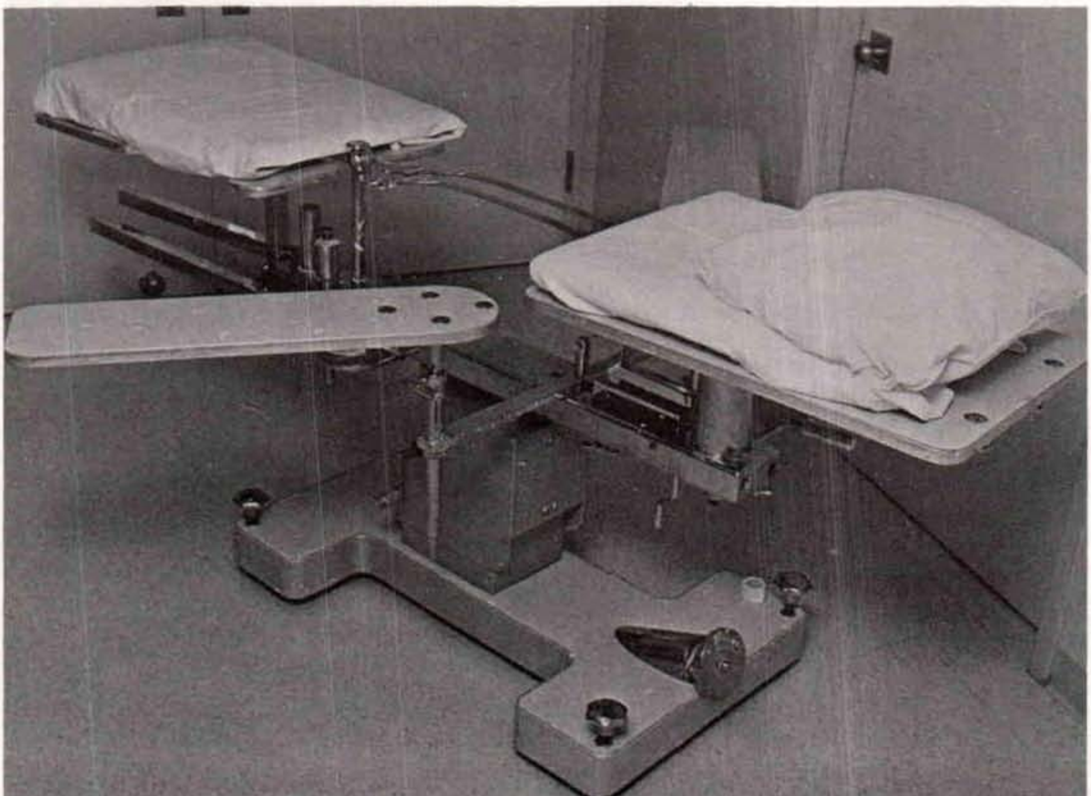

Fig. 2. Fracture table used to attain desired amount of flexion or extension of the spine.

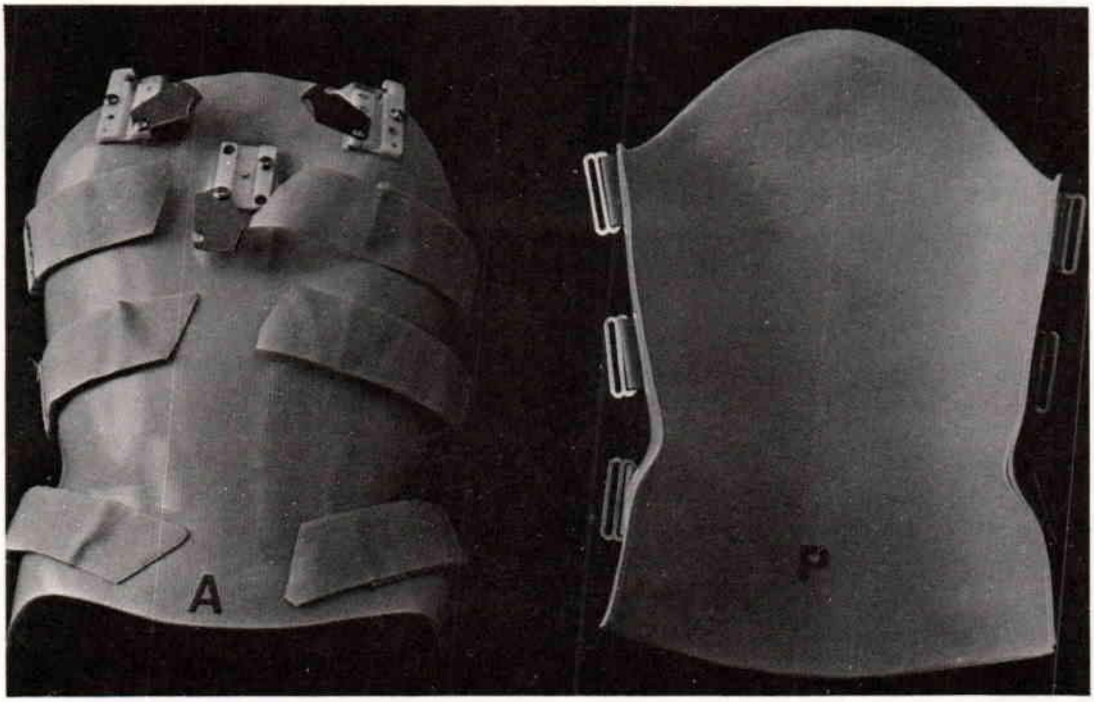

Fig. 3. Anterior and posterior shells. Note the Velcro closures, plastic channels for superstructure attachment, and the indentation over the iliac crests for suspension.

shoulder motion; over the hips to allow for enough hip flexion to sit comfortably; and superior to the buttocks so that the orthosis is not pushed up in sitting.

Lastly, six 2-in. Velcro straps, three on each side, are attached for maximum adjustability (Fig. 3). The S.O.M.I. superstructure is now attached to the superior border of the anterior shell, and adjusted to fit the patient, and holes are drilled in the shell to apply plastic channels (Fig. 4).

The S.O.M.I. type superstructure was chosen for this orthosis because the superstructure can be applied without changing the position of the patient's head since both mandibular and occipital pads are attached anteriorly; the former by a chin bar, and the latter by the curved neck support bar. In addition, to allow for easier eating, shaving, etc., the S.O.M.I. has an optional "head restraint band" which is connected to the occipital pad and wraps around the forehead. This band prevents motion of the head when the mandibular pad is removed.

FITTING

The posterior section is positioned while the patient is prone. The patient is turned to the supine position, and the anterior section is applied so that the suspension grooves are superior to the iliac crest and inferior to the 12th rib. The S.O.M.I. superstructure is inserted into the plastic channels to stabilize the head in the desired position. In this manner, the orthosis can be applied without any motion of the patient's spine (Fig. 5).

RESULTS

During the development of the orthosis 16 patients were fitted successfully. Clinically, there was no delay in healing,

Fig. 4. The S.O.M.I. superstructure and the plastic channels.

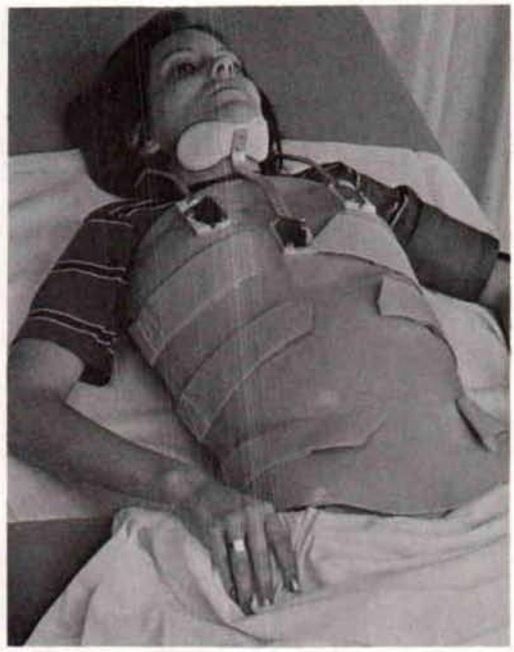

Fig. 5. Patient fitted with orthosis.

and no progression of deformity was apparent on X-ray. The orthosis is less cumbersome, and patients are up and active sooner. They can be bathed daily and possible pressure problems can be detected and corrected before decubiti have a chance to develop.

SUMMARY

The addition of a S.O.M.I. superstructure to a bivalved, laminated body jacket has proven highly effective in the stabilization of high thoracic-low cervical fractures. In most instances, the orthosis can be used safely at approximately 4-6 weeks postoperatively.

The advantages of this orthosis are:

1) It can be easily and safely donned and doffed, allowing for easier hygienic care and for periodic checks for soft tissue condition.

2) It is light in weight and less encumbering than a halo.

The construction of the orthosis is described in detail, as is the method of applying the orthosis to the patient without moving the patient's spine.

Clincal results have shown this orthosis to be an asset in the treatment of high thoracic-low cervical fractures.

Footnotes

[1]This study was supported in part by Grant #16-P-56818 from the Social and Rehabilitation Services, DHEW.

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[5]United States Manufacturing Co., 623 South Central Avenue, P.O. Box 110, Glendale, California 92109. S.O.M.I. Orthosis model #B101 less chest plate and shoulder bars.

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A New Orthotic Concept in the Non-Operative Treatment of Idiopathic Scoliosis

A Preliminary Report[1]

JOHN GLANCY, C.O.[2]

The dynamic orthosis for scoliosis presented here is a departure, in both rationale and design, from current orthotic practice. The rationale for the new system may best be explained by discussing some of the biomechanical considerations from which the rationale was evolved.

From the point of view of basic mechanics, the use of the term "dynamics" when describing scoliosis orthoses can lead to confusion. Newton's first law states "if a body exerts a force on a second body, the second body must exert an equal but opposite force on the first." Since orthoses in current use are static entities, they are limited to returning *precisely* the same magnitude of force acting upon them at any given instant.

When a wearer's trunk is upright, the weight of his or her trunk (i.e., the force of gravity) acts upon the orthosis and the orthosis can only *react* with an "equal and opposite force."

What current scoliosis orthoses do, with varying degrees of effectiveness, (depending upon factors such as type of curvature, severity, age, etc.) is to *hold* a 'prepositioned' realignment from that which the patient initially presented. However, such realignment is restricted by elastic limits, i.e., the range of motion that is present at any particular juncture throughout the length of the spinal column. Once such an orthosis is applied properly and the wearer's trunk is upright, the force of gravity still dictates the course of events, since the orthosis is limited to reacting with equal and opposite force.

Whereas it is impossible for static orthoses to generate "unbalancing" forces, it is possible to make them *alter* the *distribution* of gravity's force acting upon them. For example, whenever possible, it has become common practice to place a symmetrically formed orthosis about the scoliotic patient's asymmetric trunk. It is also common practice to alter the symmetry of the inner surface of these orthoses by attaching protruding pressure pads in order to further alter the distribution of gravity's force. In order to get a patient into such an orthosis, the force required to 'rearrange' the contours of a patient's asymmetric trunk must be supplied either by the patient's own musculature or by a person assisting the patient. Once applied, every square inch of the surface of the orthosis can but return an equal and opposite force to match the force each square inch is receiving.

When the patient is upright, the direction of the force of gravity parallels the spinal column; whereas the reaction force of current orthoses is directed primarily in a horizontal plane *perpendicular* to the column. When a wearer is recumbent, however, both the force of gravity and the reaction force of the orthosis are operative in the same plane, i.e., *perpendicular to the spinal column.* To appreciate gravity's effect when recumbent, visualize the full-length, lateral "C" curve that a normal spine can assume when a person lies on his side in a hammock slung between fixed points. It does not appear unreasonable to assume that when lying upon a flat surface, the spine must yield to gravity's force in the same manner, albeit to a lesser degree. If one accepts this assumption (given the physical makeup of the spinal column), it logically follows that the recumbent scoliotic spine within an orthosis must also yield in the same manner, but to a lesser degree. Whether the patient is in or out of an orthosis, the shoulder girdle and the pelvis are the fixed points between which the recumbent spine is 'slung'. Add the not infrequent presence of transverse rotation, wedge-shaped vertebral bodies, ligament and muscular tightness and/or contractures on the concave side, as well as the shifting of the nucleus pulposus to the convex side of the curvature(s), and very little lateral rotation between *adjacent* vertebrae within a curvature(s) is likely. When one or more of these factors is sufficient to resist gravity's force acting upon the site of the curvature(s), the individual vertebrae within the curvature(s) become "bodies at rest" and lateral motion is limited to the ends of the column. Such hammock-like motion would appear to favor movement of the overall column toward the midline, rather than

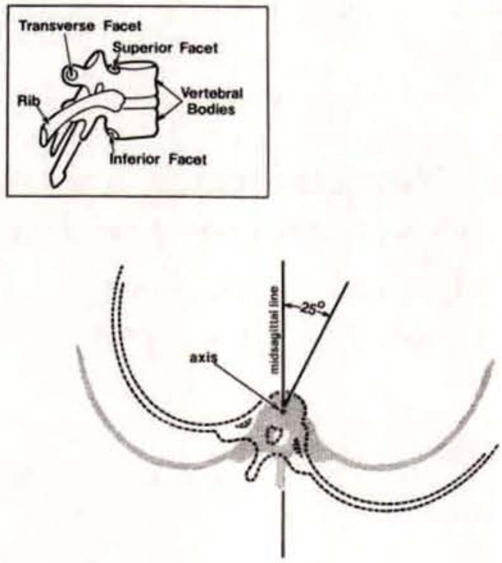

Fig. 1. Horizontal cross-sectional view: Schematic sketch of a thoracic vertebra showing that, beyond 25 degrees of transverse rotation, external force cannot be applied to the posterior aspect of the transverse process on the convex side. A rib's flexibility, coupled with the way it articulates with the vertebrae (as shown in the insert) indicates that it is a relatively weak structure. It is doubtful that a rib can transfer a force vector to a vertebra, in the same direction as it was applied, for the purpose of derotating the vertebra.

reduction of the angle(s) of a lateral curvature(s). However, tight and/or contracted musculature on the concave side of a curvature(s) can be particularly troublesome and will be discussed later.

Figure 1 illustrates the problem of reversing transverse rotation which accompanies the more severe thoracic curvatures. The schematic drawing shows that the occurrence of transverse rotation in excess of 25 deg to the midsagittal line cannot be derotated by exoskeletal means because force cannot be applied directly to the transverse process on the convex side. The insert illustrates the articulation of a rib with the transverse process of one vertebra and the bodies of two adjacent vertebrae. When a thoracic vertebra is rotated beyond 25 deg, it can be seen that external force applied to the right rib, regardless of its direction, cannot cause the vertebra to derotate. The rib, because of its flexibility, will yield to the external force without affecting the position (as viewed in the transverse plane) of the vertebrae with which it articulates.

Within the last twenty years, fine basic research has been done on the biomechanics of the spinal column and trunk. The data reported in several of these studies have had a strong influence upon both the biomechanical analysis and the rationale upon which the design criteria that is to follow was based.

FUNDAMENTAL STUDIES

Lucas and Bresler reported in 1961 (5) that the self-contained balance of forces of internal pressure within the intervertebral discs, acting against the external binding tension of the ligaments, results in a very stable arrangement between *adjacent* vertebral bodies. However, these investigators also demonstrated that the erect spine, when supported by ligaments alone, will buckle laterally under a compressive force of only four and one-half pounds (2.04 kg), or one-sixteenth of superincumbent body weight. Clinically, this condition may be compared to the state of unconsciousness or a patient with totally paralyzed spinal musculature. (2)

An *in vivo* study by Nachemson and Morris published in 1964 (7) in which they measured intradiscal pressure in the lower lumbar discs, demonstrated that there is approximately 20 percent less pressure upon these discs in the reclining position than when standing. [In context with Lucas and Bresler's findings, it is reasonable to assume that the external tension of the ligaments is also reduced by the same proportion.] In the same study, one subject was given muscle relaxants and general anesthesia; the intradiscal pressure recorded from this subject was similar to that obtained from autopsy specimens.

In discussing stabilization of the upright spine, Cotch, in 1975, (2) refers to Lucas and Bresler's study of the behavior of the spinal column to the behavior of elastic rods. Their "Column-end fixation" and four "end support situations", as they relate to a critical loading of the column when vertical, are cited. In the situation where each end of the column is free to rotate but not to deviate laterally, the critical load the spine can support is approximately one-fourth of that which it can support when both ends are fixed, as is the case in the normal vertical situation. [This suggests that the spinal column when recumbent, in or out of orthosis, is placed in the situation in which each end of the column is free to rotate laterally, since gravity's force acting upon the column is perpendicular to its long axis. However, in an intimately fitting orthosis, the 'prepositioning' would be expected to reduce the amount of motion than can occur within the orthosis, because most of the elasticity that is present will have been utilized when donning the orthosis.]

In 1974, Markolf and Morris (6) demonstrated two phenomena exhibited by intervertebral discs: 1. A decrease of the compressive load occurs as a "function of time". This "load relaxation", over long-term intervals of time, results in a constant deformation when acted upon by a given load. 2. A disc under constant compressive force has a tendency to compress with time. This behavior is termed "creep". The rate of creep increases as the force level increases. These investigators feel that these phenomena may be related to the gradual decrease in the length of the spinal column that is known to occur during the day. Since the superincumbent weight resting upon the discs within a given curvature and the equal floor reaction force are perpendicular to the floor, the effect of load relaxation and creep upon the lateral angle of a curvature would tend to increase its angle as the discs compress during the day. The horizontal reaction force provided by an intimately fitted orthosis, being equal to the superincumbent weight, blocks any further lateral rotation of the curvature. The net effect is maintenance of the status quo—a significant achievement by any standards. The question is whether progress beyond this point is possible.

Some Conclusions

From the foregoing analysis, six major conclusions were drawn with respect to the non-operative treatment of idiopathic scoliosis:

1. Current scoliosis orthoses do not appear to affect lateral curvatures beyond the elastic stage.
2. The phenomena of load relaxation and creep exhibited by intervertebral discs seems to be a crucial element to the correction of lateral scoliosis. Assuming that discs respond in the same manner to force applied to them from any given direction, their response to the perpendicular direction of gravity's force, when recumbent, would produce a "looseness" that is essential to the reduction of lateral curvatures.
3. This leaves tight and/or contracted muscles as the only known mechanical element that can block the intervertebral discs' normal response to long-term compressive forces when in the reclining position. A component of dynamic external force, acting directly upon the vertebrae within a curvature during sleep, could provide an equally essential, continuous "loosening" of contracted musculature because these muscles would be incapable of offering dynamic resistance.
4. If conclusions two and three are valid, an orthosis which has a component *capable of generating a dynamic force* directed to act upon the vertebrae within a curvature(s) should be able to effect a change in the relationship of adjacent vertebrae. Since a single vertebra only weighs a few ounces, the magnitude of a dynamic force applied to the site of a curvature does not have to be large to constitute an "unbalancing" force. The involved vertebrae must yield to a force greater than the weight of each individual vertebra to which the force is directed.
5. Floor reaction forces are as destructive as superincumbent weight. Their unimpeded travel from the floor to the site of a curvature must be controlled to permit a shifting of pressure to the convex side when upright. If such a control were applied effeciently, the Heuter-Volkman law encourages the hope that nature would have the opportunity to reverse bony deformations, *if the amount of remaining growth were sufficient to complete the process.*
6. A reasonable expectation of such a

dynamic system would seem to be a long-term, positive influence upon the plastic stage, i.e., growth, could be realized.

DESIGN CRITERIA

The design criteria from which the new system was developed follows:

- Accept the reality that when the wearer's trunk is upright, all that can be expected of any system that could be tolerated is that it is a *holding device,* whether or not the system has dynamic components.
- Therefore, if a system is to have a long-term effect upon an idiopathic scoliosis—i.e., beyond the elastic stage and on into the plastic stage in order to 'guide' growth and thereby effect a reversal of both soft and bony tissue deformations—it must provide *dynamic* forces that are operative while the wearer is *asleep.*
- The destructive elements of gravity upon the scoliotic spine when upright are generally believed to be nil when the body is in a reclined position. With all soft tissue surrounding the spinal column in a relaxed state during sleep, contracted tissue may be expected to yield to long-term dynamic pressure accurately directed to the site of the most severely contracted area, i.e., tissue within the immediate vicinity of the apex of the curve, or curves.
- However, no matter how efficiently the dynamic force is applied to the immediate area about the apex of a curve, it will not be effective unless the rest of the vertebral column is under firm control, in order to prevent diffusion of the force in the form of unwanted lateral shifting of the column as a whole. Reduction of the angle of a curve at the site of its apex should result in an overall *elongation* of the spinal column, not in lateral displacement during the night.
- The system must be adjustable in a manner that permits the overall mediolateral width of the unit to be gradually drawn in to maintain, during the day, the correction (overall elongation) attained during sleep.
- All dynamic forces within the system must be readily adjustable, especially since the forces (both in magnitude and duration) necessary to attain complete correction of a curve of a given degree and/or location, with or without bony deformations, are as yet unknown.
- However the external dynamic force is applied, derotation of curves should be a major, if not the major, purpose for its application. Without positive derotation it will not be possible to affect correction of a given curvature beyond the elastic stage.
- Consideration must be given to the effect of floor reaction forces upon lumbar curves, whether or not the pelvis is involved. Correction attained by a system during nighttime wear cannot be fully retained during the day without a method to manipulate floor reaction forces. Control of floor reaction forces cannot be achieved within the system per se, so it will be necessary to provide control in some form that acts as an adjunct to the system.

THE DESIGN

A polypropylene thoracopelvic cylinder is formed over a modified plaster-of-Paris model of the patient's torso (Fig. 2). The major purpose of the

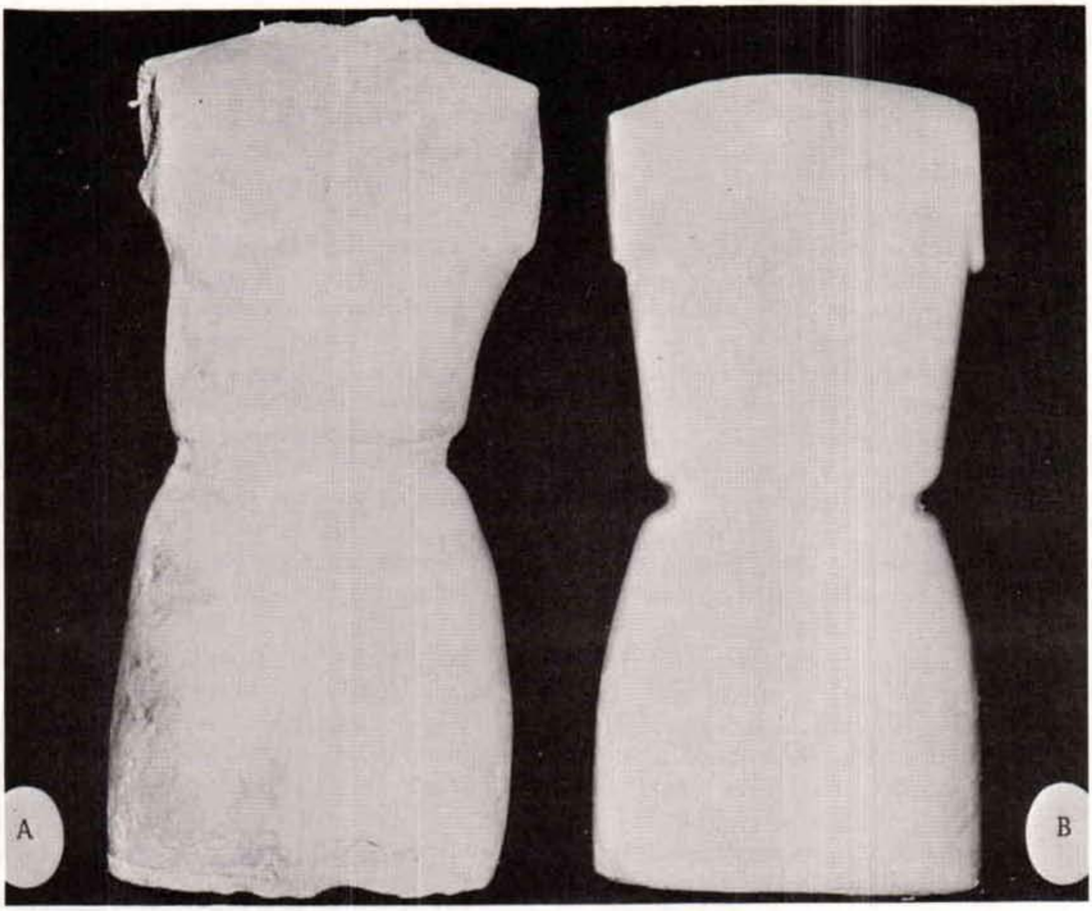

Fig. 2. Cast modifications: A. Posterior view before remodeling. B. Posterior view after remodeling.

cast modifications is to achieve a symetry of form to both sides of the model. Two important features of the "Milwaukee Brace" (1) are retained – the flattening of the abdomen and the indentations at waist level (Fig. 3) because they are efficient means of partially unweighting the lumbar region of the spinal column.

The plastic thoracopelvic form is lined with a closed-cell polyethylene foam and the waist indentations filled with Silastic elastomer. The thoracopelvic unit is cut along a vertical centerline, both front and back, into symmetrical left and right halves (Fig. 4). On a spinal X-ray film of a patient, a line, perpendicular to the floor, is drawn through the center of the body of the vertebra that forms the apex of the lumbar curve. Another line, parallel to the first, is drawn through the center of the vertebra that forms the apex of the thoracic curve. The distance between the two lines is then divided in half and that amount is cut off of both halves,

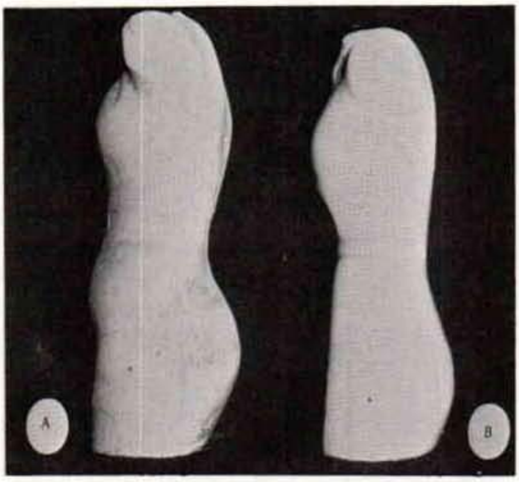

Fig. 3. Cast modifications: A. Lateral view before remodeling. B. Lateral view after remodeling. Note that an optimum amount of lumbar lordosis is retained.

along the center line, both front and back (Fig. 5) leaving a gap between both halves equal to the distance between the parallel lines drawn on the X-ray so that the two halves can be drawn together as the curves are reduced, thereby maintaining during daytime wear the reduction achieved by dynamic forces applied to the apices of the curves during the hours of sleep. Full correction of mediolateral alignment would be achieved when the mid-sagittal line passes through the center of each and every vertebral body. The two halves are joined by mounting slotted receptacles along the midline, both front and back, of one half of the unit and aluminum alignment bars that slide into the receptacles on the other half. Velcro straps prevent the two halves from sliding apart.

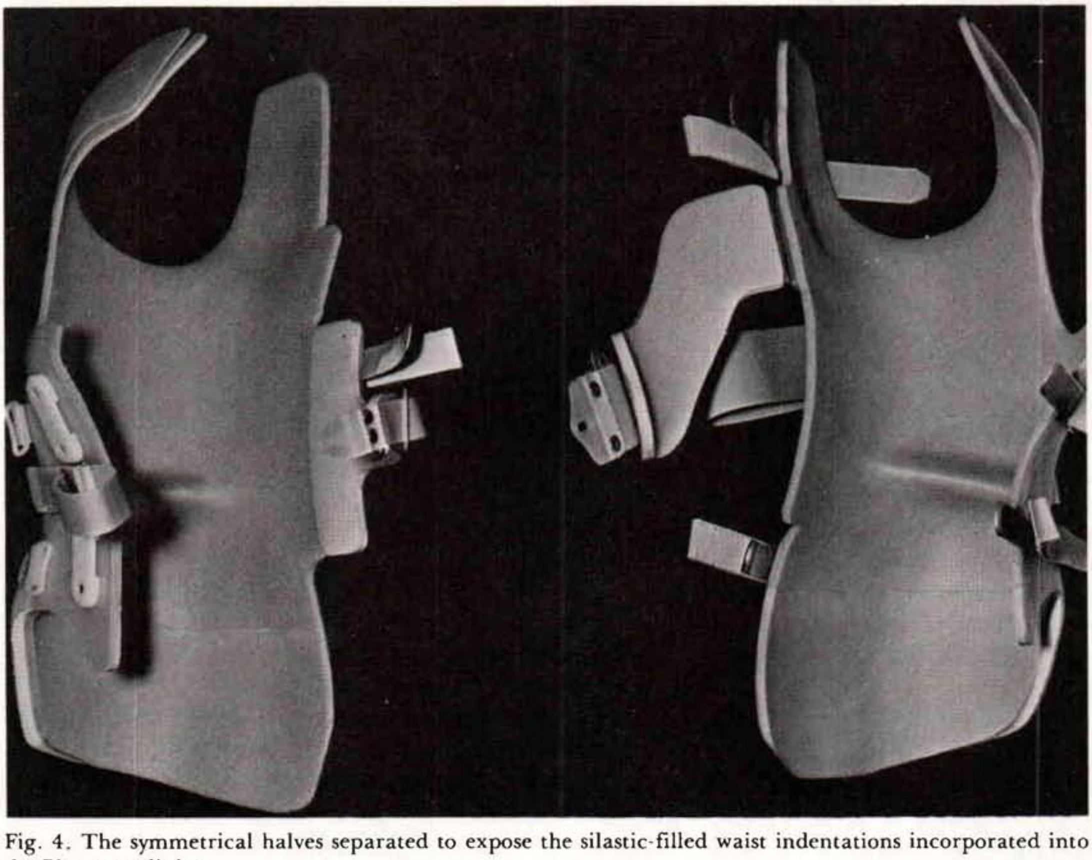

Fig. 4. The symmetrical halves separated to expose the silastic-filled waist indentations incorporated into the Plastazote lining.

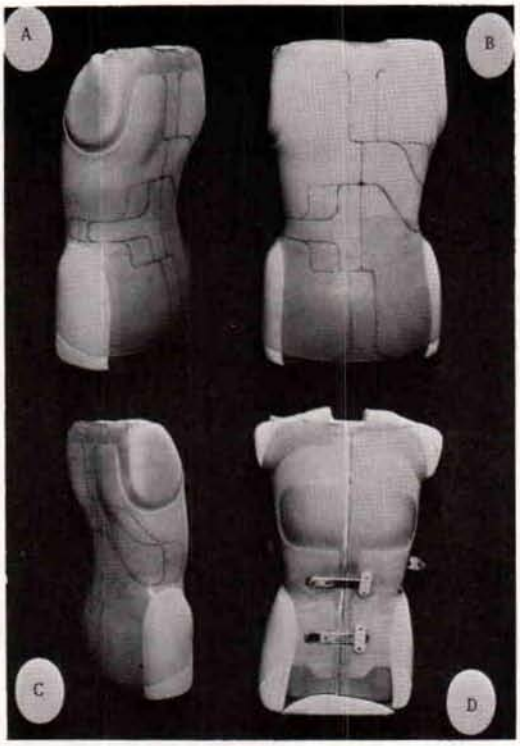

Fig. 5. Plan of the orthosis is drawn on the polypropylene form. The dotted lines indicate the amount of material that is to be cut out of the polypropylene surrounding the pressure pads to allow the two halves of the orthosis to come together. A. Left lumbar pad. B. Posterior view of the pressure pads. Note the cutouts along the center line, above and below the outlines of the pressure pads. C. Thoracic pad. D. Anterior view with the space along the center line cut away and with the aluminum bars and their recepticles attached.

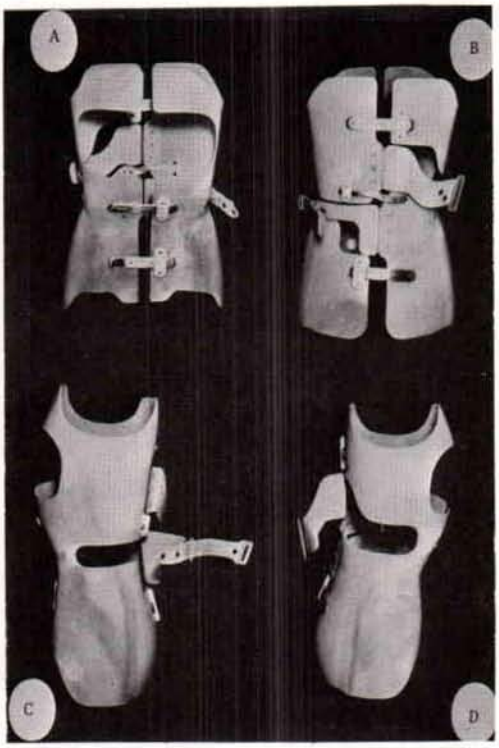

Fig. 6. The finished polypropylene form before the strapping and the lining are added: A. Anterior view. B. Posterior view. C. Lateral view with the left lumbar pressure pad with its elastic strap attached. D. Lateral view with the thoracic pressure pad swung back. (Note the gap along the center line and the cutouts around the pressure pads to allow both halves to slide together.)

The size and location of the corrective pressure pad(s) are determined from the X-ray film. The posteriomedial edge of a pressure pad is attached to the half of the unit that is contralateral to it by a polypropylene hinge (Fig. 6). Woven elastic strapping, three or four layers thick, is located so as to cross over the length of the outer surface of the pressure pad in a horizontal line. Figure 7 illustrates the type of force that can be generated and how a single force can be used to perform more than one function simultaneously.

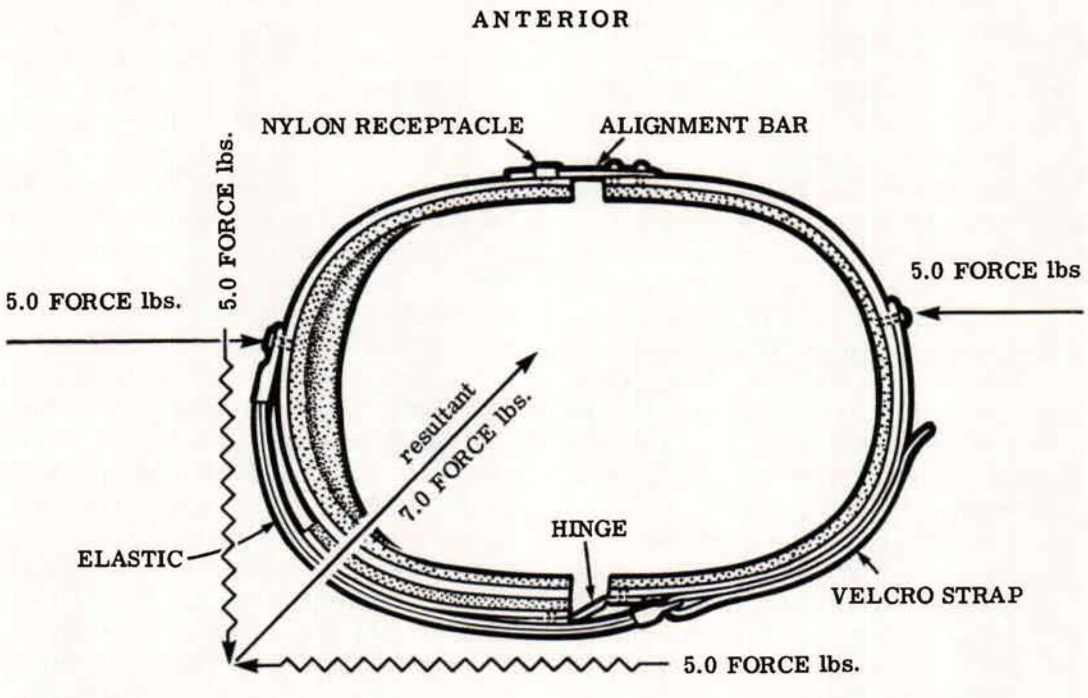

Fig. 7. Schematic sketch of the application of dynamic forces.

To visualize the multiple functions that the dynamics of the system are capable of delivering, this illustration shows a setting of 10 force pounds for a left lumbar curve. Let us say that this patient also has a compensatory right thoracic curve. Let us set the elastic acting upon the thoracic pressure pad over the curve's apex for 15 force pounds (it being reasonable to expect that the greater force will be needed to overcome the resistance of the multiple jointings of the rib cage to the thoracic vertebrae). Using the same method of calculation as shown, the resultant force acting upon the thoracic curve would be 10 1/2 force pounds, as compared to the seven force pound resultant for the lumbar curve shown in the sketch. Figuring the resultant force (as pictured) to be four inches lateral to the pad's hinge, a moment of 28 inch pounds would be acting to derotate at the site of the apex of a lumbar curvature. The 10 1/2 force pound resultant — also four inches lateral to the thoracic pressure pad's hinge — would produce a moment of 42 inch pounds to derotate. The magnitude of the horizontal vectors acting to draw the unit's two halves together would now be the *combined* force of both elastic straps generating 12 1/2 force pounds per side. The effect upon a given curvature is threefold:

1. Because the pressure pad is hinged along its medioposterior edge, the resultant vector (as illustrated) is converted to a dynamic moment that *derotates* the curvature.
2. Due to the placement of the elastic strap, the same resultant force generated by it is used to apply a dynamic inward thrust to the pressure pad which acts to *reduce* the lateral angle of the curvature at its apex.
3. The same force that is generated by the elastic strap (or straps) is utilized dynamically to draw both halves of the unit together, thus preventing the force being directed to an apex from being dissipated by unwanted sideward 'shifting' of the overall column. The overall effect is a *dynamic* three-point pressure system acting upon a curvature during sleep.

With such an interplay of dynamic forces, it seems possible to effect a continuous, positive influence upon the plastic stage for any period of time desired. It should be noted that, while the same magnitude of external force(s) that acts upon a curvature(s) during sleep is continuous during the day, the superincumbent weight, being greater, overpowers the external dynamic force. The Velcro straps convert the system to an efficient 'static' cylinder that resists the destructive elements of gravity's forces during the day. Thus, the system functions efficiently and automatically, both day and night, without conscious effort on the part of the wearer.

An explanation of the treatment of the chest area with the dynamic orthosis is needed to complete the description of its design. The choice of a modified version of conventional subclavicular extensions (in preference to a solid front) was made at the very beginning of the design's development (Fig. 5D). The open-chest feature allowed for two important functions, i.e., it provided freedom for derotation of involved thoracic vertebrae and chest expansion for ease of breathing. A receptacle and sliding aluminum bar joined the two extensions in the same manner as they are used to join the rest of the system together. A Velcro strap completed the original assembly. However, the Velcro strap proved to be too restrictive because it inhibited lateral expansion of the thorax. While the open-chest feature was thought to be adequate to accommodate for the normal tidal volumn of quiet breathing, the blocking of lateral expansion of the thorax appeared to interfere with the sigh reflex (2). To correct this important deficiency of the design, the Velcro strap across the subclavicular extensions was replaced by an elastic strap. The latter is set with one-to-two force pounds of "preload" which the sigh reflex can easily overcome.

The cushion heel lift (Fig. 8) that is used as an adjunct to the system which makes it possible to maintain correction of lumbar curvatures against the destructiveness of floor reaction forces. Figure 8A shows a left lumbar curve with an oblique pelvis. The hip on the concave (or right) side has been drawn upward with apparent shortening of the right lower limb. The large arrow above the figure represents the weight of the child's body above the level of the hip axes which is known to be approximately 50 percent of a person's total body weight (3, 4). The two smaller arrows under each heel represent floor reaction forces. It can be assumed that in normal balanced posture, both limbs are sharing the full weight of the body equally. The weight of the trunk borne by the spinal column is transferred to the pelvis, which is supporting the spinal column. The burden is equally divided and continues downward to the floor via the skeletal structures of the lower limbs. By the time contact with the floor has been made, the weight of the pelvis and each limb has been added to the vertical load that each foot is carrying. (It must be borne in mind that the leg length discrepancy is only apparent.) Thus, the child must compensate by keeping her left knee bent in order to lower her right leg so that it can contact the floor. By this compensatory flexion of the left knee, both lower limbs bear an equal share of the body's weight and overall mediolateral balance is restored. Unfortunately, such a 'no choice' com-

CONTROL OF FLOOR REACTION FORCES: THE CUSHION HEEL

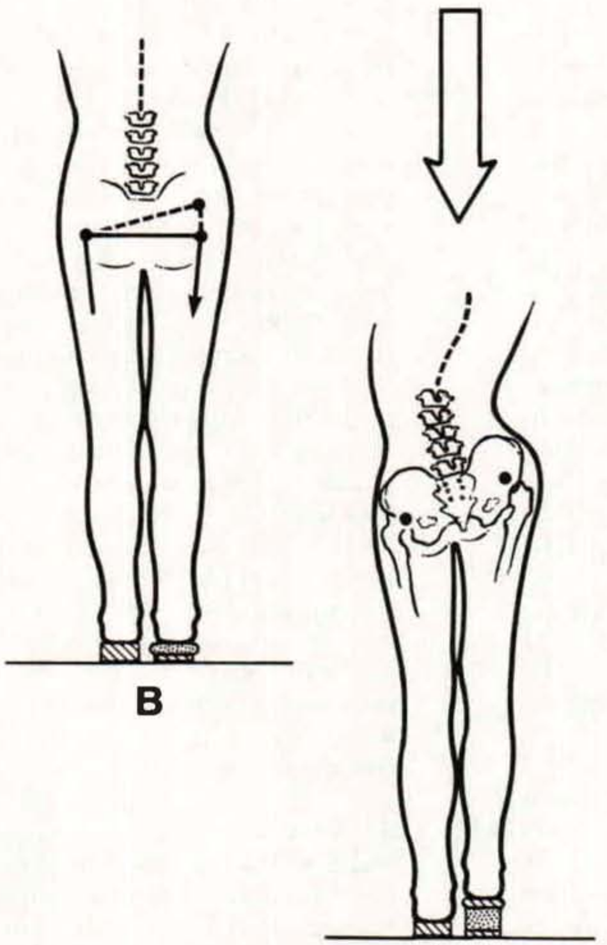

Fig. 8. Schematic sketch of the use of the cushion heel wedge as an adjunct to the dynamic scolissis orthosis: The large arrow over (A) represents the weight of the trunk. The two smaller arrows, under each heel reprsent the floor reaction force.

pensation is unable to 'right' the oblique pelvis. Let us say that the patient weighs 100 pounds. With the 50-pound trunk resting upon the pelvis and the total body weight of 100 pounds pushing back in the form of a floor reaction force of 50 pounds through each lower limb, the net effect is to 'lock in' the pelvic obliquity. Under such circumstances, it can be seen that it is impossible to apply external forces directly to the spinal column via the trunk that could overcome the enormous mechanical advantage of the floor reaction force.

The cushion heel manipulates floor reaction forces by putting these forces to work to help correct that which they have wrought. The effect is achieved by adding, for example, a half-inch *solid* heel lift under the heel of the limb on the convex side of a curvature and a *cushion* heel lift of a half-inch, plus an additional thickness equal to the pelvic obliquity, under the 'short' limb on the concave side. Figure 8A shows the child bearing her full weight upon her fully extended left leg which has a solid heel lift under it. The sketch attemps to show the subject the instant before she begins to shift half her weight onto the right limb with a cushion heel lift under it. A rapid sequence of events occurs, as follows:

1. As weight is received by the cushion heel lift under the 'short' limb, the cushion absorbs a portion of it and thereby causes a delay in that portion of weight reaching the floor.
2. The fact that both hip joints have a normal range of motion makes it possible to manipulate floor reaction forces in a way that forces the oblique pelvis into a position parallel to the floor. Whereas, a portion of the weight being placed upon the cushion heel lift under the 'short' right limb is delayed for an instant on its way to contact with the floor, the full amount of the weight passing downward through the left limb reaches the floor *without* delay, therefore, a floor reaction force of equal magnitude travels up instantaneously through the left limb to the left hip. As the floor reaction force reached the level of the hip on the left side, the slight delay due to absorption by the cushion (only a very short period of time is necessary) has automatically reduced the magnitude of the floor reaction in its upward travel through the right or 'short' limb. The weight of the trunk, pelvis and right leg may be said to be 'falling free' during the instant delay. Their combined weight overcomes the weight of the left limb forcing rotation of the pelvis about a sagittal axis about the left hip joint.
3. The cushion heel compresses and becomes firmer as the amount of weight upon it rapidly increases and results in a proportional increase in the floor reaction force travelling up to the right hip. However, the floor reaction force will continue to be somewhat less in magnitude than it is in the left limb because the initial delay cannot be overcome until the cushion heel has 'bottomed out'. At the instant the cushion heel has compressed into as firm a platform as the one under the left heel, only then will the floor reaction force under the right heel be equal, in *timing* and *magnitude,* to the left side.
4. As resistance to the descending trunk and pelvis builds in the right limb — due to the rapidly increasing floor reaction force travelling up the the hip joint — the heavier weight from above will cause the necessary degree of rotation to occur about the right hip joint to complete the levelling of the pelvis, *before the*

floor reaction force under both feet become equalized.

The weight of the patient determines the durometer of the cushion material to be used. The material must not 'bottom out' before the pelvis is parallel to the floor. It must also be thick enough to allow the amount of 'drop' necessary to level the pelvis. The equalization of the floor reaction forces 'locks' the pelvis into its level position. This result occurs automatically whenever the patient is standing. A unilaterally cushioned seat can be provided which will, in the same manner, level the pelvis while in the sitting position.

What effect can the levelling of an oblique pelvis be expected to have upon a lumbar curvature? It depends on the tightness and amount of foreshortening of a musculature and other soft tissue on the concave side of the curvature at the time the cushion heel is applied. Figure 8B is a schematic illustration of what may be expected when the lumbar curvature is mild and flexible. It seems reasonable to expect that an intimately fitted *passive* plastic cylinder, with the assistance of a cushion heel lift, should maintain the spine in balance. The schematic drawing (Fig. 8C) shows the lateral shift of the entire trunk to the concave side that results when the musculature and other soft tissue on that side are tightly contracted and the pelvis is leveled without an orthosis. Obviously, the dynamic scoliosis system cannot release the contracted soft tissues as soon as it is applied. Time will be needed for its dynamics to achieve correction beyond whatever small amount of elasticity may be present. The tightness of the contracted tissues makes an immediate levelling of the pelvis, as shown in Figure 8C, unacceptable. Therefore, when the dynamic system is first applied, the right hip will be much as shown in Figure 8A, but with a slight compression of the cushion heel lift. It is in such cases that the cushion heel lift is an essential adjunct to the dynamic scoliosis system. For as the dynamic system begins to reduce and derotate the curvature over the long term, the cushion heel lift allows the hip on the concave side to become parallel with the ground gradually as the contracted tissues respond to the system's dynamics. The manipulation of the floor reaction forces is the same as previously described, except that instead of a level pelvis being attained in a matter of seconds (as was true of the case shown in Figure 8B,) the process may take weeks— or if necessary, months—to complete. Throughout the necessary time span, instead of floor reaction forces 'locking in' the pelvic obliquity during the day and thereby reversing any correction of the curvature obtained by night, the weight of the "semi-suspended' right limb is used to place all soft tissue on the concave side on stretch through the day.

Two major improvements to the original design were added later:

First, removable side pads were added. The dynamic drawing together of the two halves of the unit maintains the correction achieved by the pressure pads during sleep. Reduction of the angle of the curve(s) results in elongation of the spine and thereby also reduces the mediolateral width of the thorax. It became apparent that a way had to be found to retain the rigidity between the rib cage and the pelvis (which is vital to the system) and still accommodate for the variance in mediolateral width between the correcting spinal column and the relatively 'fixed' diameter of the pelvis.

Figure 9 shows two removable pads that are incorporated into the sides of the pelvic portion, between the lining and the outer polypropylene form. They are made of one-eighth to one-fourth-inch-thick firm, closed-cell polyethylene foam. Selection of the thickness of these pads is dependent upon the severity of the curve(s) and the age of the patient. As the spinal column elongates, the pads can be

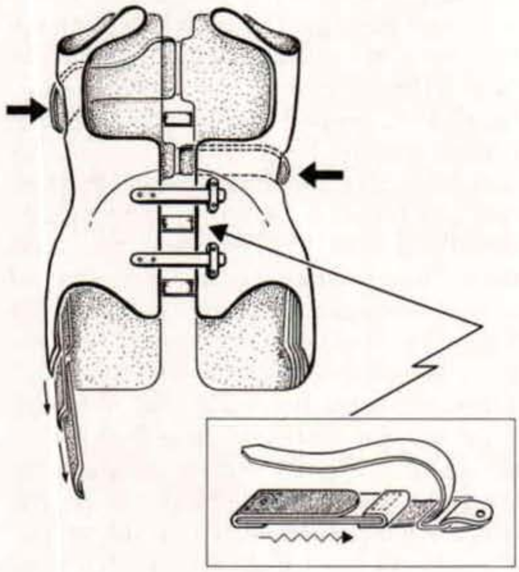

Fig. 9. Schematic sketch of the removable, lateral pelvic pads with the elastic 'balancing' strap shown in the insert.

removed in any order desired, thus ensuring a continuous, positive influence along the thoracic spinal column. When correction has been achieved, the systen is worn as a prophylactic during the remaining period of bony growth. Also, during the prophylactic period the removable pads can be utilized to accommodate the maturing pelvis as its mediolateral width broadens.

Second, an anterior elastic 'balancing' strap was added. The greater resistance that a more rigid anatomic structure presents initially to the dynamic force being applied to the pressure pad(s) caused the two halves of the unit to migrate around to the center of the back, where their medioposterior edges butted against each other. This butting stopped any further drawing in of the two halves and, consequently, blocked any further correction by the pressure pad(s). In short, the system became a *static* holding device both *night* and day.

An elastic 'balancing' strap, as shown in the insert in Figure 9, was added to the abdominal portion at approximately waist level. The tension of this strap is set to approximate the force(s), as previously described, acting to draw both halves of the unit together. This elastic does not increase the overall force being applied to the two halves. Its function is to eliminate rotation of the two halves about the trunk, by directing the force(s) acting upon the two halves toward the midsagittal line of the trunk, thus restoring the dynamics to the system.

SUMMARY OF DESIGN CRITERIA

Static orthoses are limited to reacting with an equal and opposite force to the weight of the trunk. As a consequence, the magnitude of force required to manipulate, or 'preposition', a curvature must be applied before and/or during the donning of these orthoses. A new dynamic scoliosis orthosis has been developed that utilized components that generate dynamic forces that act upon a curvature(s) while the wearer is asleep. The rationale and design criteria from which the orthosis was developed is described in considerable detail. The components and the function of the dynamic orthosis have been described in full.

RESULTS

To date, twenty-two idiopathic scoliosis patients and one eight-year old female with hypophosphatasia have been fitted

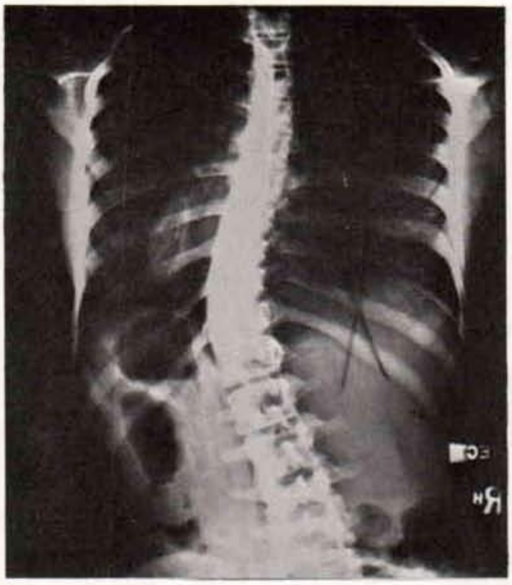

Fig. 10. Patient D.H.: Left lumbar of 32 degrees with a pelvic obliquity and a right thoracic of eight degrees. A dynamic pressure pad was directed to the site of the lumbar curve with a setting of 10 force pounds. A dynamic pressure pad was not used for the mild thoracic curve. This film was taken on March 13, 1976. The patient was then 14 years and one month old.

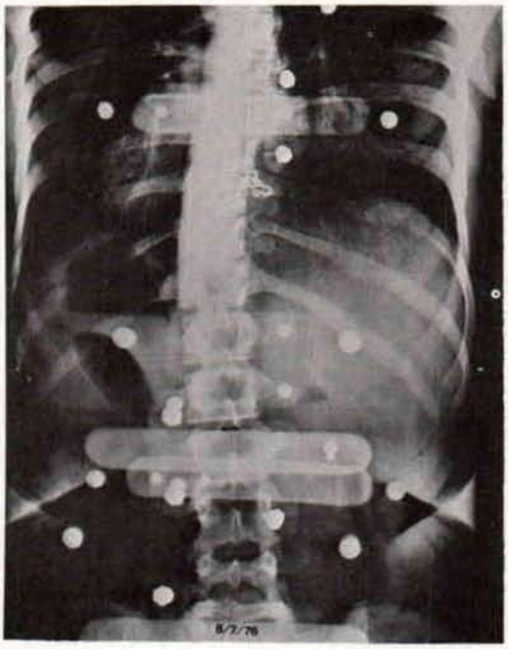

Fig. 11. Film taken August 7, 1976, three weeks after D.H. received her dynamic orthosis, which replaced an earlier one which did not function properly.

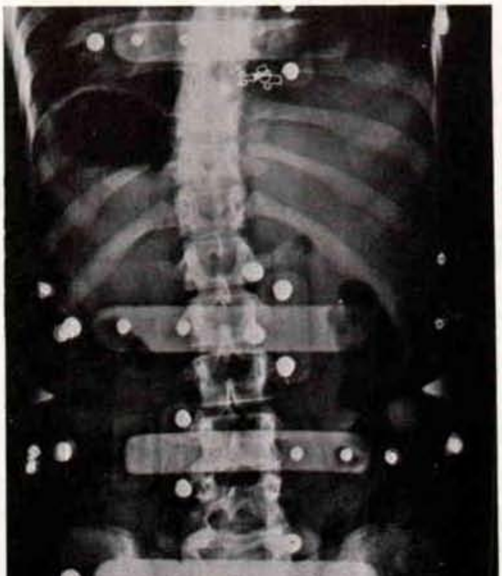

Fig. 12. Film was taken August 1, 1977. This orthosis which is the same D.H. wore in Figure 11 was an early prototype and did not have the improvements referred to in Fig. 13.

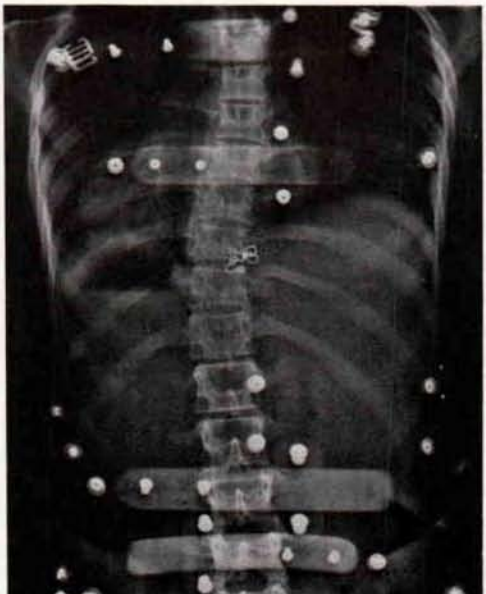

Fig. 13. Film was taken October 21, 1977, three months after she had received a new orthosis that has the removeable pelvic side pads, the 'balancing' strap and the elastic strap joining the subclavicular extensions. Patient had outgrown the pelvic portion of her previous orthosis.

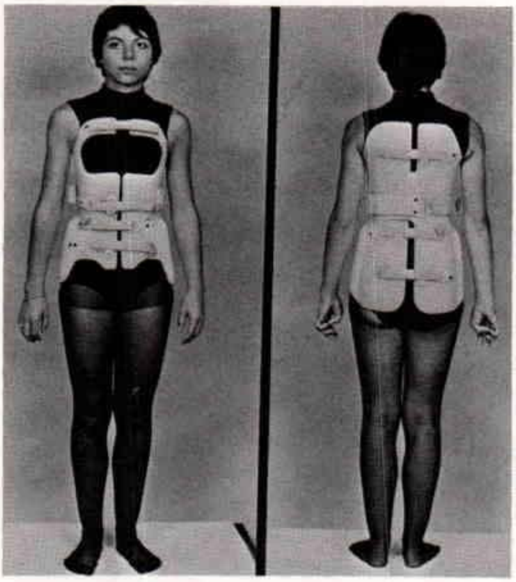

Fig. 14. Patient D.H. wearing her dynamic scoliosis orthosis. Note the narrowness of the midline openings in front and back which relates to correction achieved.

with the new orthotic system. The patients are representative of a variety of curvatures. Curvatures with an apex at T8 are the highest that have been attempted. The majority of those patients have been wearing a dynamic orthosis for less than a year. There is much to be learned about the skillful use of the new orthosis as a tool in the non-operative treatment of scoliosis. It is still too soon to evaluate the effects of its long-term use. However, results to date have been gratifying and it would appear that the concept of the use of dynamic forces that are operative while the patient sleeps is valid. The progress of one patient is shown in Figures 10-14.

Footnotes

[1]Portions of this report were presented at the 1977 World Congress for Prosthetics and Orthotics in New York City, May 27-June 2, 1977; the National Assembly of the American Orthotics and Prosthetics Association in San Francisco, October 25-29, 1977; the Fourth Annual Roundup Seminar of the American Academy of Orthotists and Prosthetists in Orlando, January 19-21, 1978; the University of Kentucky seminar "Orthotics and Biomechanics" in Clarksville, Indiana, February 2-4, 1978, and educational seminars sponsored by the American Academy of Orthotists and Prosthetists in Region VI (December, 1976), Region V (October, 1977), and Region IV (November,

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New Underarm Three-Point Holding Orthosis for Management of Low Scoliotic Curves

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The use of underarm-level orthoses for the management of thoraco-lumbar and lumbar scoliotic curves (2, 3) is a recent idea stemming directly from the "Milwaukee Brace", with the main goal being to relieve the patient from the cervical superstructure.

Hereby described is an orthosis developed in the Zamenhoff Orthotic Laboratory in colaboration with the Scoliosis Unit of the Department of Orthopedics and Traumatology of the Beilinson Medical Center. The aim of this design was to produce an efficient, three-point holding force system acting on the convex side of the scoliotic curve and thus to achieve a maximal correction.

The orthosis (Fig. 1) consists of the following parts:

a. the pelvic cage

b. two upright bars (anterior and posterior)

c. a horizontal underarm bar

d. a lumbar holding pad.

The pelvic cage is constructed of a thermoplastic material. It rests on both iliac crests, leaving the waist area open. Special care is taken to eliminate lumbar lordosis. For this purpose the cage is brought low in the region of the buttocks but is cut sufficiently high in the front to permit comfortable sitting. The abdomen must

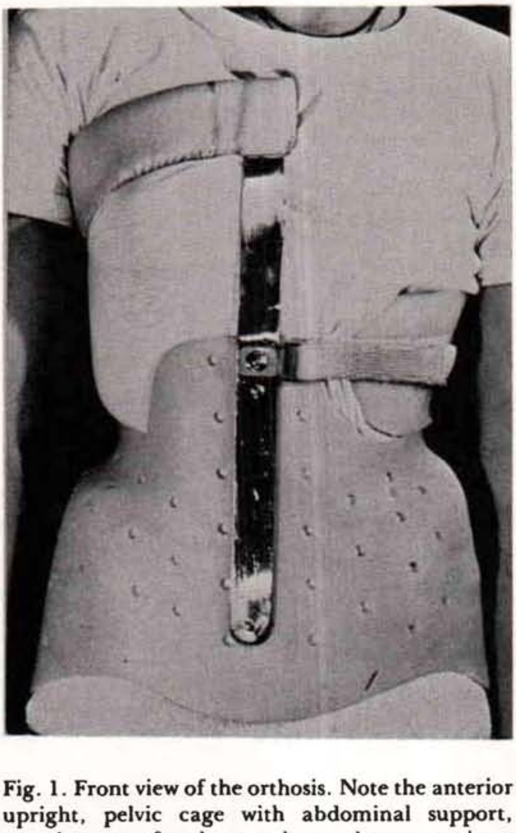

Fig. 1. Front view of the orthosis. Note the anterior upright, pelvic cage with abdominal support, anterior part of under-arm bar and canvas strip to lateral holding pad.

Fig. 2. Posterior view of the orthosis, showing bayonet shaped upright connected with the horizontal underarm bar. Note downward deflexion of the arm-pit bar and position of the lateral holding pad.

be kept firmly supported in order to prevent lumbar lordosis and to ensure an effective correction when the lateral force is applied by a holding pad. Two metallic upright bars, anterior and posterior, rise from the pelvic girdle to the level of the arm pits. Whereas the anterior bar is straight (Fig. 1), the posterior bar is bent and bayonet-shaped (Fig. 2). The lower end of the posterior upright is fixed to the pelvic cage 7 to 8 cm lateral to the midline on the concave side, bringing the upper part of the "bayonet" above the spinous process of the thoracic vertebrae. Both uprights reach equal height. Their upper ends are connected by means of a horizontal bar which passes under the arm pit on the concave side and is a half-ring shape to fit the individual form of the chest and breast. A slight downward deflexion of this bar is necessary to avoid shoulder elevation (Figs. 1 and 2). The holding pad, which is made of thermoplastic material, exactly fits the convex side of the patient's waist. This pad is attached to the posterior bar with a joint and by means of a canvas Velcro-strip to the anterior upright bar. It must be positioned exactly against the top of the scoliotic curve so that tightening of the canvas strip exerts a direct corrective force on the curve.

DISCUSSION

The three-point holding system, a principle utilized in the "Milwaukee Brace", has proved to be an effective aid in the correction of scoliotic curves and prevention of deformities (1). The design described above utilizes the same principle and acts similarly to the Milwaukee Brace, with the corrective force exerted by a holding pad placed against the top of the curve. This force is opposed by the pelvic cage and the half-ring under-arm bar. Lowering of the upper "opposing" point limits the effectiveness of the orthosis to the lumbar and thoraco-lumbar regions alone, but in these regions it has proved to be useful in correcting scoliotic curves, particulary those between 20 to 40 deg. (Figs. 3 and 4).

SUMMARY

Idiopathic scoliosis remains a challenge to the orthopedic surgeon and orthotist. In recent years the use of orthoses has been found to be a useful method of preventing an increase in the developing curve and the "Milwaukee Three-Point Brace" has proved to be the most effective in this respect. The need to wear a brace with a superstructure which cannot be concealed by ordinary clothing is a source of considerable inconvenience

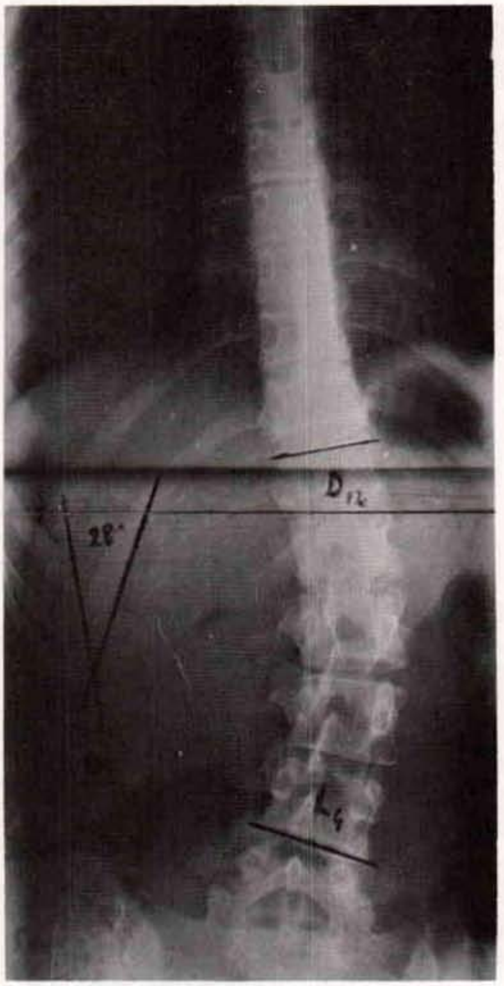

Fig. 3. X-ray of the spine in a 13-year-old girl with right dorsolumbar scoliotic curve of 28 degrees.

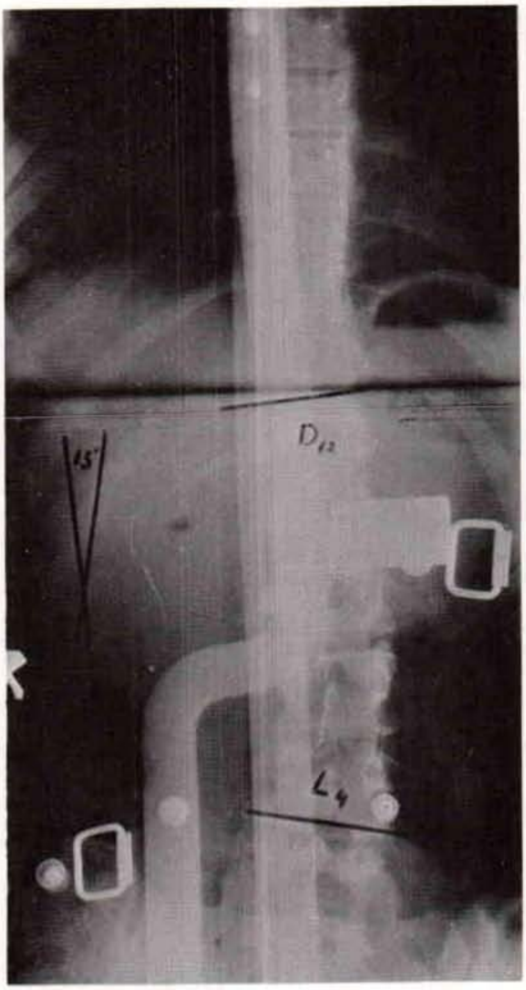

Fig. 4. X-ray of the patient shown in Figure 3 wearing the brace. Correction of the curve to 13 deg. was achieved immediately.

and embarressment to the patient. For this reason an effort is being made to construct an orthosis which eliminates the neck piece but is still based on the three-point holding principle.

Our experience has shown that this type of orthosis satisfactorily provides an adequate correction of the scoliotic curves in the lumbar and dorso-lumbar regions.

Footnotes

[1]The Zamenhoff Orthotic Laboratory and the Department of Orthopedics and Traumatology, Beilinson Medical Center, Petah Tiqva, Israel.

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The "Gillette" Sitting Support Orthosis

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During the past four years the Orthotic and Prosthetic Laboratory at Gillette Children's Hospital has developed a Sitting Support Orthosis which has become very important in the treatment of our non-ambulatory children with severe cerebral palsy or advanced Duchenne Muscular Dystrophy (Fig. 1). The Gillette Rehabilitation Therapy Department has also been very actively involved in the development and use of the Sitting Support Orthosis. Their knowledge of the problems associated with cerebral palsy has ensured that the orthosis not only addresses these problems but is compatible with and complementary to the rest of the child's adaptive equipment and his daily routine. Specific problems of concern are those of feeding, communication, reflex patterns, abnormal muscle tone, and learning potential in addition to spinal support and deformity. The medical staff of our Cerebral Palsy Service, our Spine Service, and our Growth and Development Service has provided the impetus, encouragement and support for the project.

Fig. 1. The "Gillette" Sitting Support Orthosis with anterior thoracic support and head support.

BACKGROUND

The development began on our Cerebral Palsy Service. Most cerebral palsy children who do not acquire the ability to ambulate lack the balance or voluntary means to have a good sitting posture in their first decade of life. They sit in a kyphotic or kyphoscoliotic posture. The pelvis is often not horizontal. In some cases, balance, voluntary control, and sitting posture improve rapidly enough so that the flexible spine deformity of the first decade does not become a rigid, progressive deformity during the second decade. However, a significant portion of non-ambulatory cerebral palsy children do progress during the second decade to a serious spinal deformity. The spine curvature may make sitting very difficult or eventually even impossible. Pelvic obliquity can aggravate the symptoms of a dislocated hip. Cardio-pulmonary function may be seriously compromised. Another important consideration is that a small but significant portion of these patients have an average or superior intelligence. Their education, social interaction and self-esteem is very important and greatly affected by their sitting posture and function.

Better head control, whether it comes indirectly through stabilization of the thorax or directly by head support, is extremely important. A child who is looking chronically straight down or straight up or sideways at the world is deprived of normal avenues of discovery, stimulation, and social interaction.

The child with Duchenne Muscular Dystrophy begins to develop a spinal deformity about the time he becomes non-ambulatory. The deformity progresses to become a very large single curve, that includes rotation, scoliosis, and either kyphosis or lordosis. The spine deformity sometimes affects cardio-pulmonary function and almost always causes a sitting posture so poor that the patient's functions are seriously compromised long before he would lose the function because of other manifestations of his disease.

Our approach on seating in the past has been to utilize the hospital's carpentry shop to construct wedged seats with upholstered lateral supports, an approach very common around the country and that is successful to some degree. However, it does not control adequately the location and orientation of the pelvis. Lack of contoured conformance to the anatomy results in a concentration of the pressures generated by gravity. The padded, upholstered sides of the seat are too bulky to extend lateral thoracic support sufficiently high in the subaxillary area. Even the best of these seats accomplished very little in the way of real spine support.

THE GILLETTE SITTING SUPPORT ORTHOSIS

The Sitting Support Orthosis developed here at Gillette consists of a custom-molded, plastic shell mounted on a base. The plastic shell conforms to the body contours posteriorly and laterally from the knees to the upper thorax. The base provides the proper support to the shell and allows the unit to be removed from the wheelchair for use in the car or other places. A lap belt is provided to hold the pelvis snugly back into position. The hips are positioned in the amount of flexion recommended by the physical or occupational therapist. Since reflex patterns in severe cerebral palsy are frequently affected by the degree of hip flexion, we follow the recommendation of the occupational or physical therapist. These children also very often have overactive hip adductors. The pommel prevents excessive hip adduction, and it also helps to prevent the patient from sliding out of the seat. In the case of muscular dystrophy the hips are positioned as close to 90 degrees of flexion as possible. The pommel is usually not necessary and is eliminated in favor of easier usage of the urinal. Figure 2 is an example of a Sitting Support Orthosis for a child with advanced muscular dystrophy.

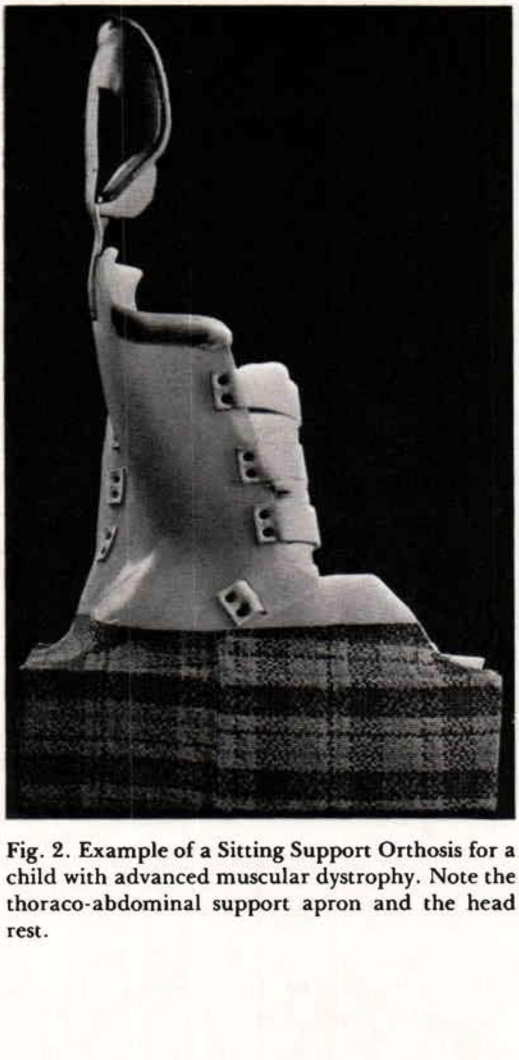


Fig. 2. Example of a Sitting Support Orthosis for a child with advanced muscular dystrophy. Note the thoraco-abdominal support apron and the head rest.

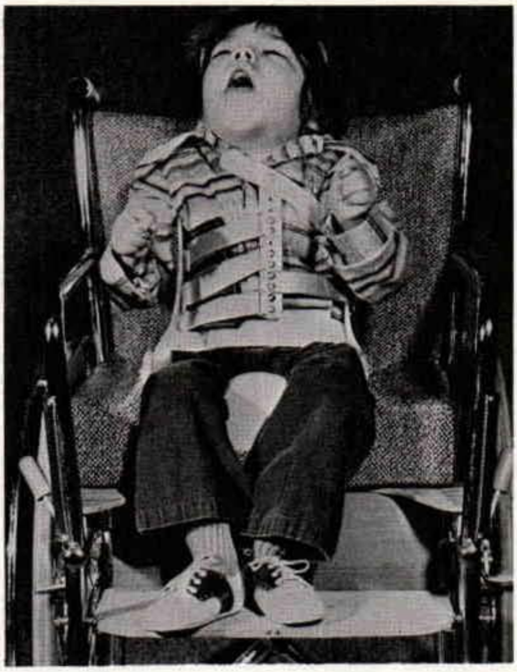


Fig. 3. This child's orthosis includes a fabric panel which provides thoraco-abdominal support to the convex aspect of his spine curvature.

Various anterior components are added as necessary. A lordotic muscular dystrophy patient will need a large abdominothoracic apron to pull him upright. For the kyphotic patient, a fabric halter or rigid, custom-contoured, subclavicular support may be necessary, depending on the force required to obtain an acceptable posture.

When a significant scoliosis exists, aprons are designed to pull one side or the other. To accomplish this without unduly constraining the thorax, we have borrowed the anterior upright feature from the designers of the Milwaukee Orthosis. In the case of a convex left curve, for instance, a cloth thoracic panel is anchored to the inside posterior of the shell a few centimeters to the left of center. The panel extends around the left side of the trunk (at the appropriate level) and attaches to a central anterior upright (Fig. 3). Usually, a well-padded axillary sling is attached in a similar manner on the right. The anterior upright is supported by means of a hinged outrigger

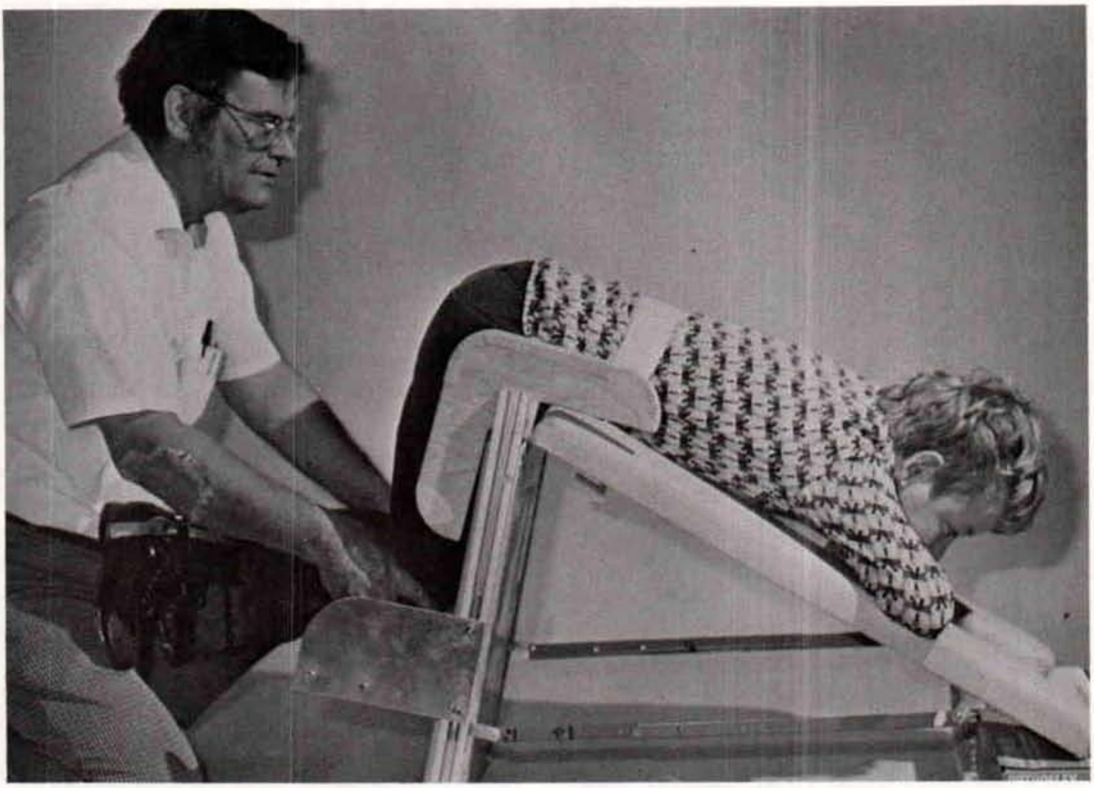


Fig. 4. The patient is placed on a padded "A" frame in a well-aligned, face-down position.

extending from the right side of the shell. To remove the patient from orthosis, the panel is loosened from the anterior upright, and the upright and outrigger are swung out of the way to the right. On rare occasions, we have installed lumbar pads for additional spinal column support.

Stabilizing the thorax obviously aids the patient's voluntary head control, but sometimes additional head support is necessary. In some cases, head control is used continuously to prevent certain head positions and the reflex patterns which are triggered by those positions. In other cases, it is appropriate to make the head support removable so that it may be used part-time only or for feeding. This is another aspect of the design which requires consultation with an experienced therapist who has had a chance to become acquainted with the child.

The exact angle of recline is not decided until fitting the orthosis to the child. We try to bring the child as nearly as practical to a vertical sitting position.

The thin plastic shell design permits us to extend our lateral thoracic support right up to the axilla without impinging uncomfortably on the medical aspect of the arm. This support eliminates most of the collapsing action of gravity.

When the child wishes to roll around and play on the floor, supporting hardware is automatically left behind in the chair. He is free to roll or scoot around unencumbered. When the child is horizontal, gravity is not operating to collapse the spine.

FABRICATION

Fabrication of this Sitting Support Orthosis begins with an accurate impression of the child in the sitting posture desired. The patient is positioned face down on a padded "A" frame (Fig. 4) with hips and knees held flexed. The amount of hip flexion is usually 90 to 100 degrees. Bony areas such as the trochanters, ischial tuberosities and coccyx are covered with masking tape and outlined with lipstick on the tape. Gravity and gentle but firm hands work together to position the child in the most optimum position attainable. We try to put the cerebral palsy patient, for instance, in a relaxed position of reduced thoracic kyphosis, reduced scoliosis, and as much lumbar extension as possible. His hips are held in enough flexion to break up his spastic extension reflex pattern and in a few degrees of abduction. His shoulders are abducted 90 degrees. In this position, a sealed PVC bag one-third full of polystyrene foam beads is lowered onto the child and tucked around him and between his legs (Fig. 5). The air is exhausted from the bag, and the mass of beads become solid (Fig. 6). The bag is pulled off the child, turned over and the impression ex-

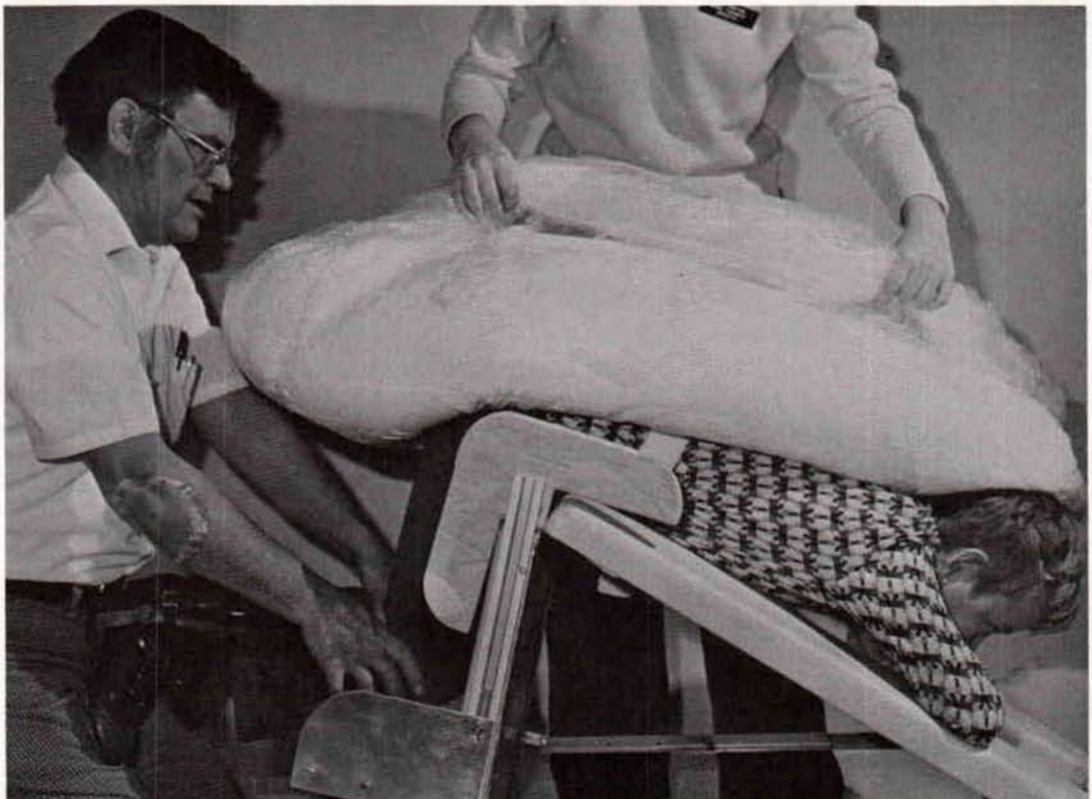


Fig. 5. A PVC bag, one-third full of polystyrene foam beads, is lowered onto the posterior surface of the child and packed around him.

Fig. 6. Exhaustion of air solidifies the bag of beads.

amined. If the impression is satisfactory, the lipstick marks are reinforced with indelible pencil, and the impression is filled with plaster to create the positive model. If it is not satisfactory, air is leaked back into the bag, and the process is repeated.

Measurements are taken of the wheelchair so a properly fitting base will be applied to the seat insert. Other measurements are taken so that rough trim lines may be established at the hamstring tendons and the axilla. Lateral-lateral diameter measurements are taken at the distal thigh, trochanters, waist and axilla for reference during cast modification.

During cast modification, the usual surface defects are remedied, all diameters are brought to measurement, and position inadequacies during the impression stage are now corrected. Plaster is added to create reliefs at the trochanters, ischial tuberosities and coccyx, as needed.

Cotton stockinet is drawn over the finished model, and it is covered (drape and vacuum assist method) with hot 0.5 cm. polypropylene. Rough trim lines are established, and a cast saw is used to cut the shell from the model.

A rough, oversized cut-out is made in an "Ethafoam" block, and the shell is foam mounted in the block, using a two-part isocyanate foam. The posterior incline of the back of the shell is usually less

Fig. 7. Child with severe cerebral palsy assuming a typical unsupported, kypho-scoliotic sitting position.

Fig. 8. Child shown in Figure 7, now in the Sitting Support Orthosis.

than 10 degrees.

When fabrication has reached this stage, the child is brought in for fitting. With the child positioned in the rough shell, final trim lines can be established and optimum attachment points determined for lap belt, apron, head support, etc. The X-rays are very helpful in determining the best location for supporting panels on scoliotic patients.

RESULTS

As of March 1, 1978, we have fitted 156 Sitting Support Orthoses. Of this total, 133 were for children or adults with cerebral palsy, and 23 were for children with advanced Duchenne Muscular Dystrophy.

The Sitting Support Orthosis has been very successful in several ways. The system has proven capable of providing the stabilizing support necessary for a near-normal sitting posture (Figs. 7 & 8). Head control or position is nearly always improved, sometimes dramatically.

The orthosis usually improves the child's comfort and position to the point that the intensity of reflex patterns and abnormal muscle tone are reduced. Stability provided by the Sitting Support Orthosis frees up the child's hands in some cases where they would otherwise be used for support. This also means the child does not have to try to pay attention to so many things and can better concentrate on such things as head control, communicating, or learning in the classroom. The orthosis has also greatly improved or simplified the sometimes very difficult task of feeding these children.

Quantifying the effect of the "Gillette" Sitting Support Orthosis on the long term development of spine deformity is obviously very difficult and not yet possible. We are currently only reporting examples of immediate improvement in sitting posture and spine alignment. Figure 9 is the A-P X-ray of the spine of a child with cerebral palsy. Figure 10 shows spine alignment for the same child in the Sitting Support Orthosis.

Figure 11 is the lateral X-ray of a child with advanced Duchenne Muscular Dystrophy. The belly-on-thigh posture illustrated in this X-ray is very unfunctional and uncosmetic. Figure 12 is the lateral X-ray of the patient in his Sitting Support Orthosis. Figure 13 is a photograph of the patient in his orthosis. The muscular dystrophy patients are very pleased that the orthosis helps them regain a more normal sitting stature and report easier breathing due to less crowding of the abdominal cavity. The upper thorax and shoulders are free enough to aid in elbow control, hand placement, and head placement.

DISCUSSION

The Sitting Support Orthosis must fit quite closely to be effective. The child

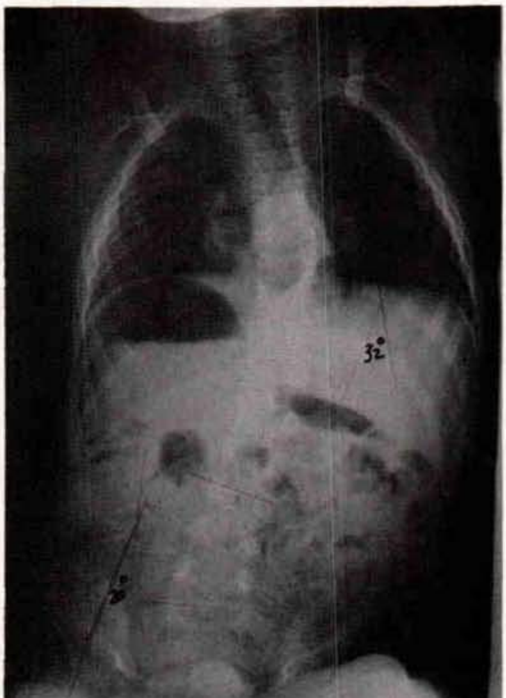


Fig. 9. The A-P X-ray of a child with severe cerebral palsy.

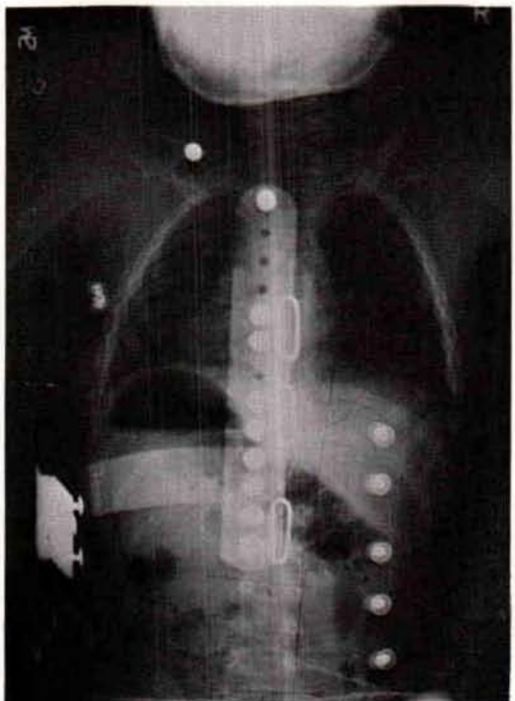


Fig. 10. The A-P X-ray of the child shown in Figure 9 and his Sitting Support Orthosis.

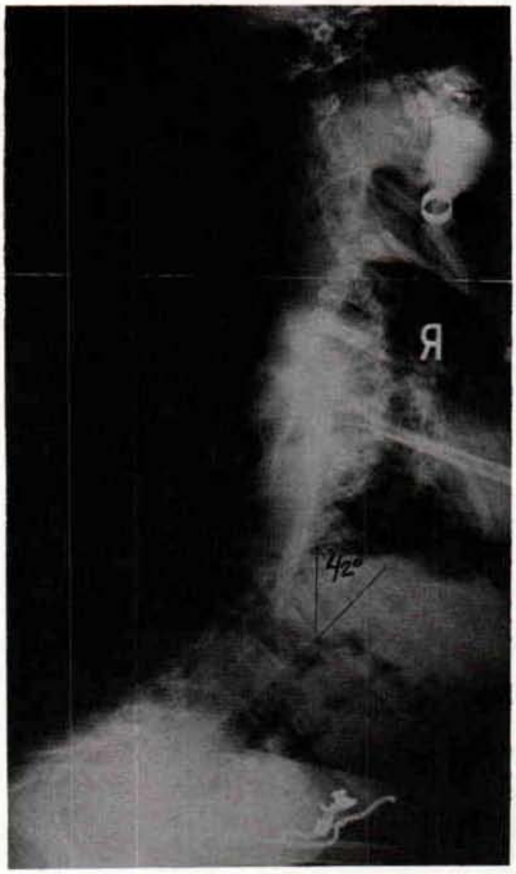


Fig. 11. Lateral X-ray of a patient with advanced Duchenne Muscular Dystrophy. Even this poor belly-on-thigh posture required the two-handed support of his mother anteriorly.

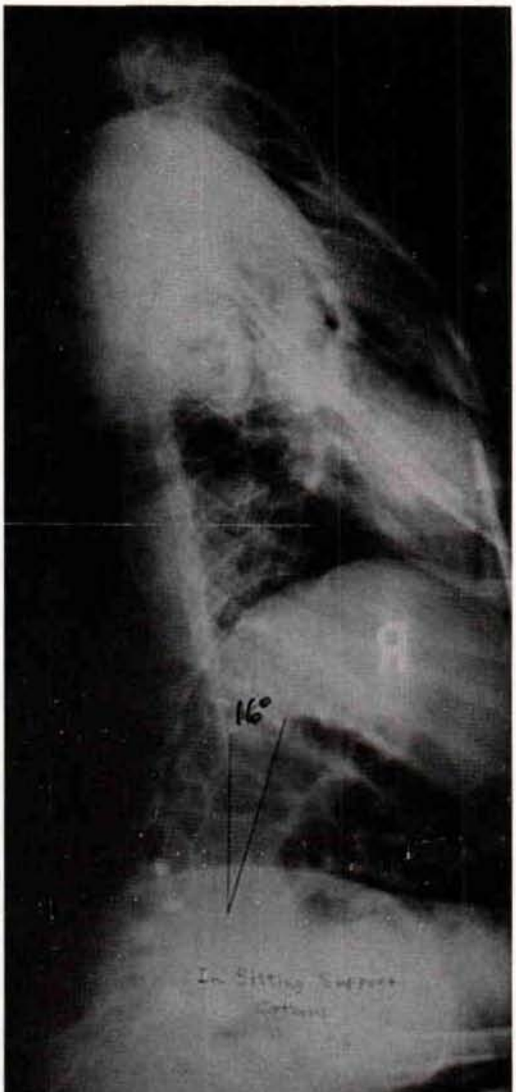


Fig. 12. Lateral X-ray of patient shown in Fig. 11 in his Sitting Support Orthosis.

will not fit in his orthosis when bundled up in heavy winter clothing. Sometimes it is advisable for the child to be in his orthosis during school bus rides, and the temperature may be quite low. The orthosis can be accommodated under a winter coat by using a larger size or making simple adaptations. The orthosis is outgrown usually between eleven and twenty-five months after fitting.

The involvement and cooperation of the entire health team creates an overall equipment system which works because the various components are compatible, and the important problems in the child's life are recognized and dealt with. Figure 14 is a photograph of a child with cerebral palsy and his Sitting Support Orthosis, wheel chair, and lap board with

Fig. 13. Patient with advanced Duchenne Muscular Dystrophy in his Sitting Support Orthosis.

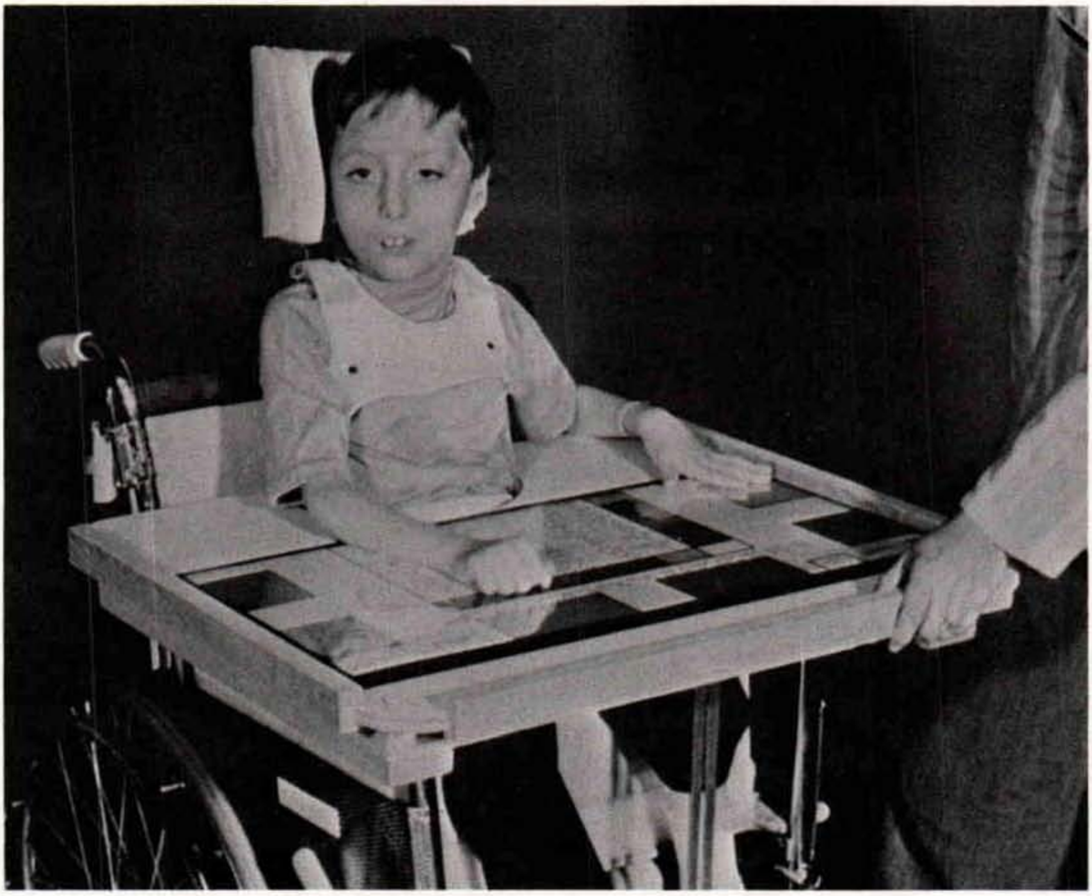


Fig. 14. Child in his wheelchair with Sitting Support Orthosis, lap board, and communication system.

in-laid communication figures.

Our most enthusiastic response and encouragement and many valuable design suggestions have come from the parents, teachers, therapists, nurses and other people who teach or care for the child in the community. These people who live or work with the child on a daily basis know better than anyone the current effect of treatment on the total child.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the important contributions to this development made by Fran Hollerbach, Mary Hatung, Scott Weber, Gene Berglund, Arturo Vazquez Vela, and other Orthotic and Prosthetic Laboratory staff members; Jan Headley, former Rehabilitation Director; Diane Twedt, Rehabilitation Therapy Supervisor; Karen Beck, Martha Talmadge, Marilyn Kochsiek, Sue Swanson, Collette Carlson, and Lee Schuveiller, Rehabilitation Therapy staff members; Dr. Thomas Comfort, Dr. Lowell Lutter, and Dr. John Lonstein, Gillette orthopedic staff members; and Dr. Richard Zarling, neurologist, Fairview Hospital. Photography is by Gordon Dunn and Ken Jandle. The manuscript was typed by Linda Frattalone.

[1]Gillette Children's Hospital, St. Paul, Minnesota

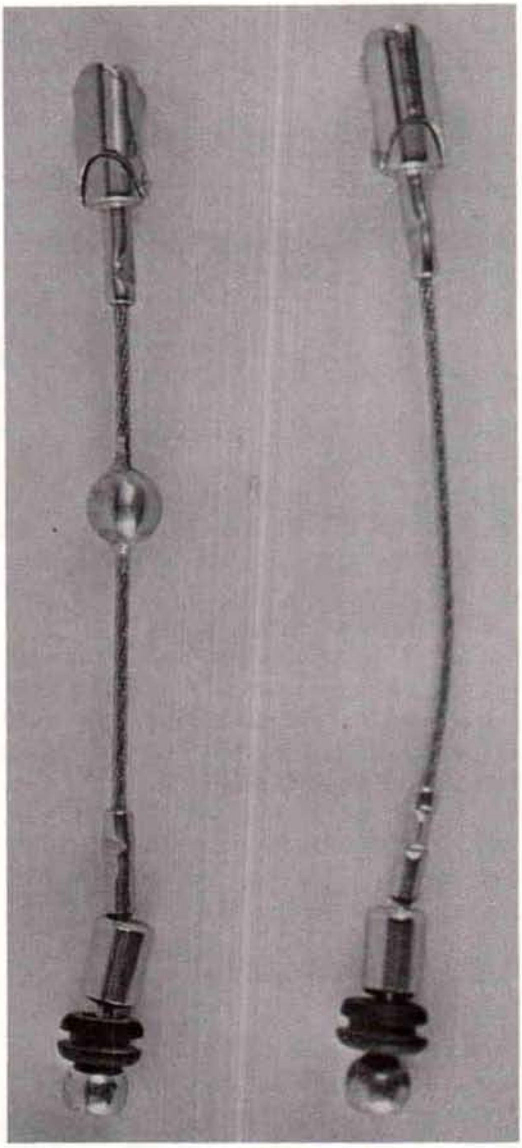
Orthotics and Prosthetics, Vol. 32, No. 4, PP. 46-47, December 1978

TECHNICAL NOTE

A Modified Hook-to-Cable Adaptor

Short above-elbow and shoulder-disarticulation prostheses present a unique problem to the prosthetist, one that is not found in most other upper-limb prostheses. Because of the short length of the residual limb, there is less excursion available in the control system. When excursion is lessened, the patient may be able to flex the prosthetic forearm to only 90 deg. with little or no terminal device opening, unless an excursion amplifier of some type is used.

Although an excursion amplifier will work for some patients, it does not work for all. Because the excursion is reduced, the amount of force required by the patient to raise the forearm is frequently more than the patient can deliver. In the case of an excursion amplifier on a shoulder-disarticulation amputee, it usually requires the axilla strap to be buckled tightly at all times, a condition that proves to be very uncomfortable to the patient. The sliding of the amplifier across the plastic socket creates an unpleasant noise during the operation of the prosthesis. Furthermore, the sheave on the excursion amplifier system tends to clog with lint from clothing and may cease to turn, causing the cable to rub and fray, requiring repair of the cable.



To eliminate these problems, a substitute method has been employed successfully by us. This consists of a modification of the hook-to-cable adaptor. A steel ball (Fig. 1), approximately 5/16 in. in diameter with the center drilled out to allow the cable to pass through, it soldered proximally to the triple swivel ball terminal on the hook-to-cable adaptor. When the prosthesis is raised to its maximum position of flexion, the triple swivel ball terminal is removed from the thumb of the hook and the slack in the cable is taken up by placing the steel ball into the thumb of the hook. With the cable in a tightened position, the patient can now go further into flexion and, hopefully, into full hook opening in the full elbow flexion position. The few centimeters of cable extending distally to the thumb of the hook have not proven to be a problem of interference in any way. The changing maneuver of triple swivel ball terminal to steel ball, back to the triple swivel ball terminal is easily and speedily completed with the sound hand.

By using this type of hook-to-cable adaptor, I have found it possible to harness most patients in the conventional manner, eliminating almost completely the need for extra and uncomfortable straps, excursion amplifiers, external elbow assists, etc.

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The following resolution was adopted by the Board of Directors of the American Orthotic and Prosthetic Association at its meeting in San Diego October 3, 1973:

WHEREAS by Act of Congress it has been determined that the United States should proceed towards adoption of the metric system as used almost universally throughout the rest of the world, and

WHEREAS the technological professions and many segments of the health professions have commonly used the metric system over an extended period of time, and

WHEREAS it is important for members of the orthotic/prosthetic professions to interact with their colleagues in the medical and technological communities for optimum patient service be it hereby

RESOLVED that the American Orthotic and Prosthetic Association endorses the use of the metric system by its members and other orthotic and prosthetic practitioners in the United States, and in witness of this endorsement and Association urges the editors of its journal *Orthotics and Prosthetics* to commence the dual reporting of weights and measurements in both the English and metric systems at the earliest possible date with the objective of employing the metric system solely by the time of the 29th Volume in 1975.

METRIC SYSTEM
Conversion Factors

LENGTH

Equivalencies

angstrom	= 1×10^{-10} meter (0.0 000 000 001 m)
millimicron*	= 1×10^{-9} meter (0.000 000 001 m)
micron (micrometer)	= 1×10^{-6} meter (0.000 001 m)

To Convert from	To	Multiply by
inches	meters	0.0254†
feet	meters	0.30480†
yards	meters	0.91440†
miles	kilometers	1.6093

AREA

To convert from		
square inches	square meters	0.00063616†
square feet	square meters	.092903

VOLUME

Definition

1 liter = 0.001† cubic meter or one cubic decimeter (dm^3)
(1 milliliter = 1† cubic centimeter)

To convert from	To	Multiply by
cubic inches	cubic centimeters	16.387
ounces (U.S. fluid)	cubic centimeters	29.574
ounces (Brit. fluid)	cubic centimeters	28.413
pints (U.S. fluid)	cubic centimeters	473.18
pints (Brit. fluid)	cubic centimeters	568.26
cubic feet	cubic meters	0.028317

MASS

To convert from	To	Multiply by
pounds (avdp.)	**kilograms**	**0.45359**
slugs‡	kilograms	14.594

FORCE

To convert from	To	Multiply by
ounces-force (ozf)	newtons	0.27802
ounces-force (ozf)	kilogram-force	0.028350
pounds-force (lbf)	newtons	4.4732
pounds-force (lbf)	kilogram-force	0.45359

*This double-prefix usage is not desirable. This unit is actually a nanometer (10^{-9} meter = 10^{-7} centimeter).
† For practical purposes all subsequent digits are zeros.

STRESS (OR PRESSURE)

To convert from	To	Multiply by
pounds-force/square inch (psi)	newton/square meter	6894.8
pounds-force/square inch (psi)	newton/square centimeter	0.68948
pounds-force/square inch (psi)	kilogram-force/square centimeter	0.070307

TORQUE (OR MOMENT)

To convert from	To	Multiply by
pound-force-feet	newton meter	1.3559
pound-force-feet	kilogram-force meters	0.13826

ENERGY (OR WORK)

Definition

One joule (J) is the work done by a one-newton force moving through a displacement of one meter in the direction of the force.

1 cal (gm) = 4.1840 joules

To convert from	To	Multiply by
foot-pounds-force	joules	1.3559
foot-pounds-force	meter-kilogram-force	0.13826
ergs	joules	1×10^{-7}†
b.t.u.	cal (gm)	252.00
foot-pounds-force	cal (gm)	0.32405

TEMPERATURE CONVERSION TABLE

To convert °F to °C $$°C = \frac{°F - 32}{1.8}$$

°F	°C
98.6	37
99	37.2
99.5	37.5
100	37.8
100.5	38.1
101	38.3
101.5	38.6
102	38.9
102.5	39.2
103	39.4
103.5	39.7
104	40.0

***A slug is a unit of mass which if acted on by a force of one pound will have an acceleration of one foot per second per second.**

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3. LEGENDS. List all illustration legends in order, and number to agree with illustrations.
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   b. Original drawings or charts

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3. Indicate BIBLIOGRAPHICAL REFERENCES by means of Arabic numerals in parentheses (6).
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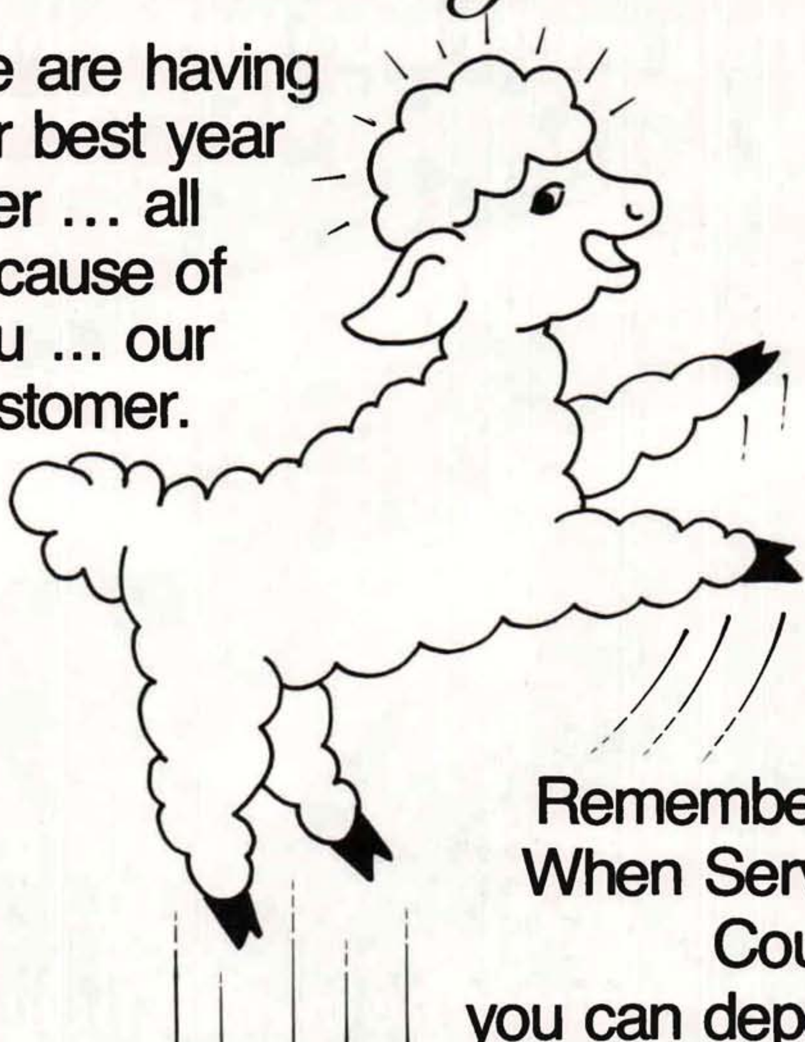

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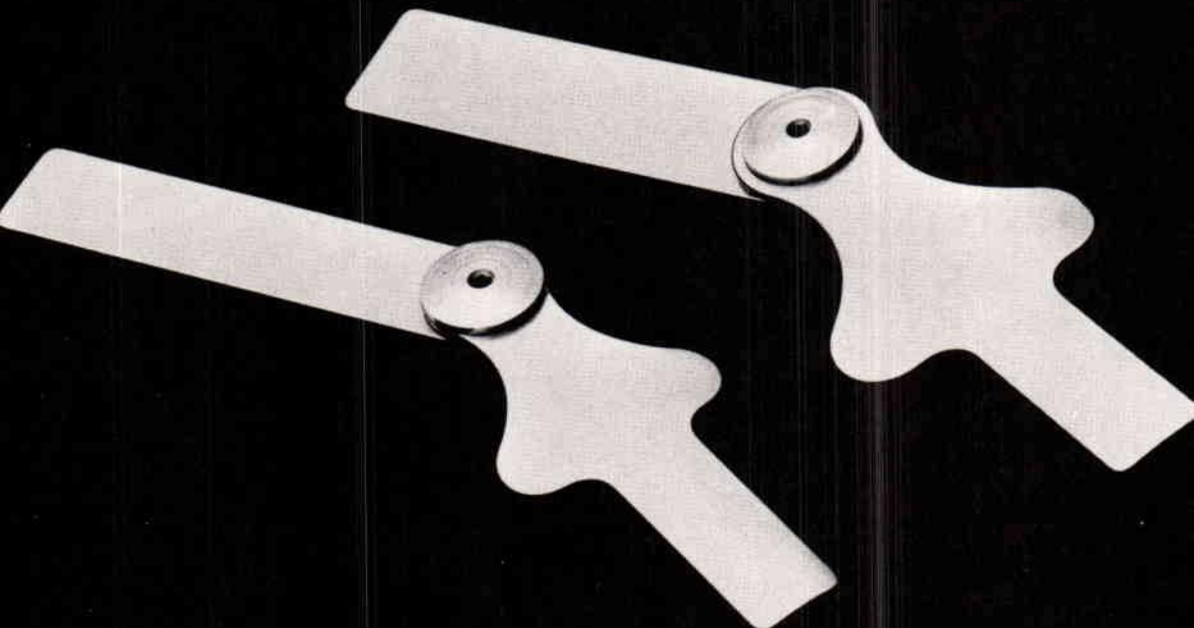

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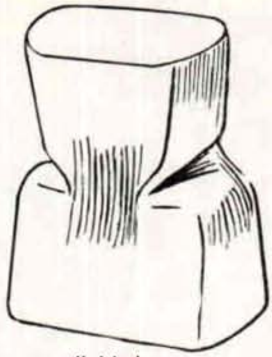

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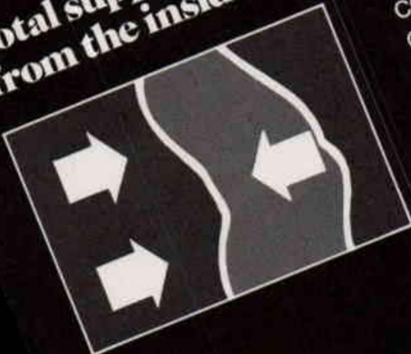

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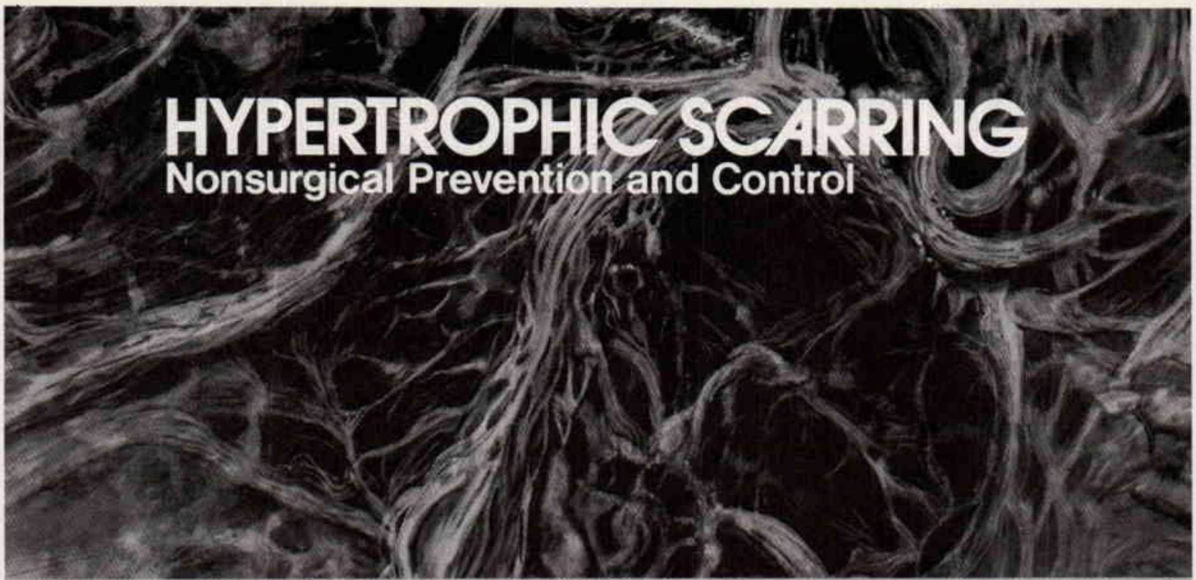

Substructures – whorls and twisted collagen bundles

One of the surgeon's most frustrating problems of the patient's post-burn recovery period has been the insidious onset of deforming and crippling hypertrophic scarring and contracture. Very often, the burn patient will leave the hospital apparently healed only to return later as the integument takes on the grotesque characteristics of belated substructure induced hypertrophy. Substructure because bundles of collagen beneath the surface, generally parallel in their arrangement in normal skin, have rearranged into random whorls and twists causing the overlying surface itself to rearrange unless it is splinted by the pressure of underlying bony prominences.

Superstructures – Jobst® Anti/Burnscar™ Supports

Hypertrophic scarring can be prevented by applying pressure to the skin by means of topical superstructures.[1] When these carefully measured, custom-made and fitted Jobst Anti/Burnscar Supports are worn by the patient in a controlled regimen, unruly rearrangement of collagen is discouraged. The superstructures are extraordinarily efficacious in soft anatomical areas where underlying bony support and splinting are absent.

In many hospitals and burn centers, both occupational therapists and physical therapists are assisting the surgeon in the proper measurement, fitting and application of Jobst Anti/Burnscar Supports. Please write for complete details and medical references:

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1. Larson DL: The Prevention and Correction of Burn Scar Contracture and Hypertrophy. Shriners Burns Institute, University of Texas Medical Branch, Galveston, Texas 1973.
2. Malick, Maude H., O.T.R. Management of the severely burned patient. Occupational Therapy, April 1975, pp 76-80.

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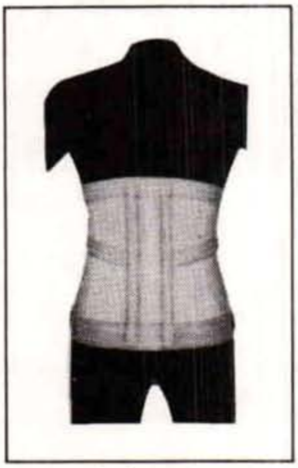

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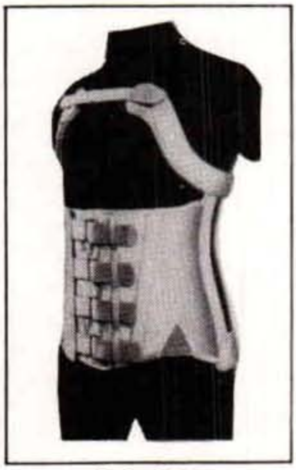

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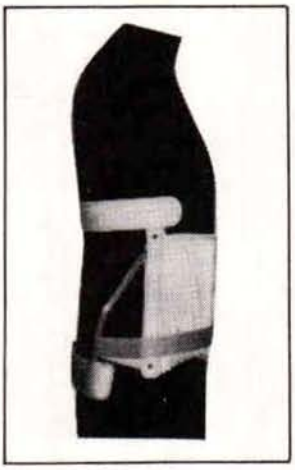

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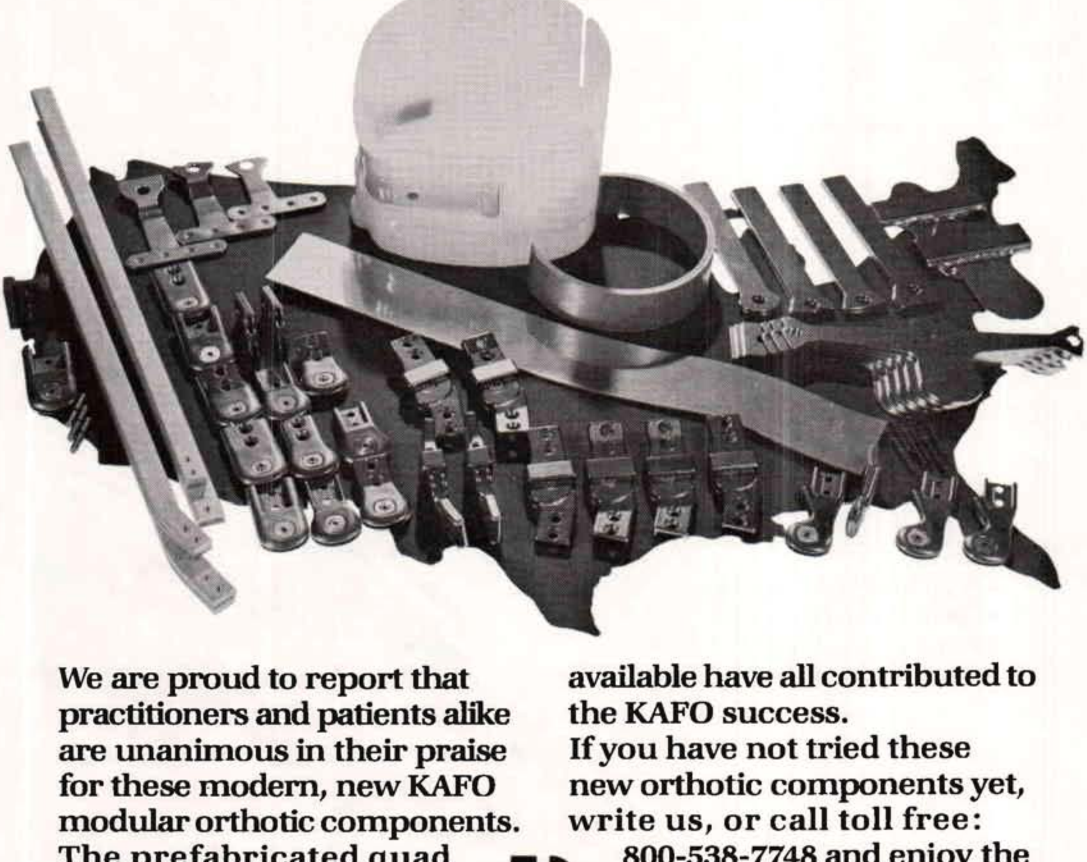

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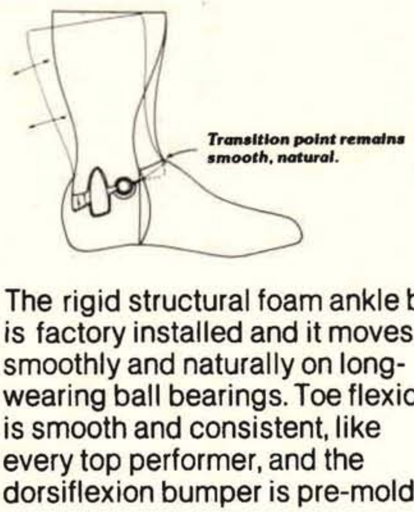

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