Engineering Principles and Fabrication Techniques for the Scott-Craig Long Leg Brace for Paraplegics

by Bruce A. Scott, C.P.O.

(Ed. Note: The accompanying article was almost completed by Bruce Scott, C.P.O., Denver, Colo., prior to his death. The introductory section describes the circumstances of development of The Scott-Craig Long Leg Brace for Paraplegics.

Dr. Harry R. Hahn, a member of the developmental team, said in a recent letter to the National Office:

"I am extremely pleased that you are planning to publish the article and dedicate it to Bruce. He, as you undoubtedly well know, was the true brains behind the concept of the fixed ankle, and to my way of thinking it is the most significant basic change in lower extremity bracing concept since the Germans made the first caliper.")

The engineering principles of the Scott-Craig long leg brace can best be described by saying that it takes advantage of Newton's Third Law of Motion—that for every action there must be an equal and opposite

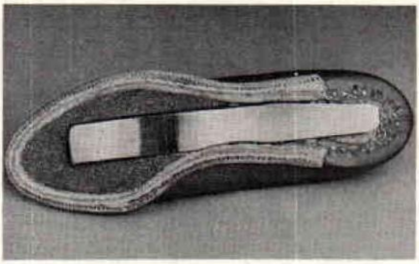

Fig. 1

A longitudinal plate of spring steel is imbedded in the insole.

reaction—in that the shoe attachment is designed so that the hip joint can be left free and the center of gravity of the patient can be used to provide control of balance during standing.

The Scott-Craig long leg brace was developed by a group at the Craig Rehabilitation Center over a period of about ten years in an effort to provide the paraplegic patient who has a complete neurologcal level above L1 with more function and comfort than is possible with previously known braces (1).

Shortly after his accident, nearly every paraplegic patient wants to be fitted with orthoses immediately, so that he can "walk again." Early fit-

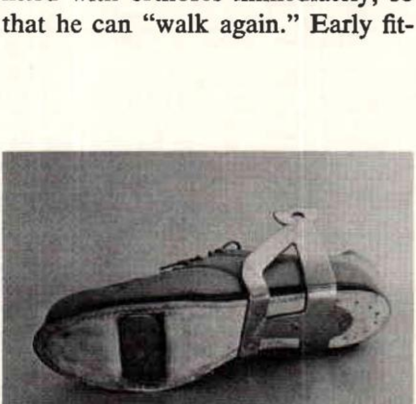

Fig. 2

View showing installation of the transverse plate and the reinforced stirrup.

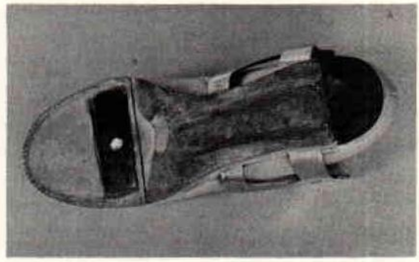

Fig. 3

A wedge-shaped leather soling is installed to cover the bottom of the reinforced stirrup.

ting provides psychological advantages only when the braces prove to be useful; that is 1) when they provide the necessary stability for balance without an excess of hardware, and 2) when they provide ease of donning and doffing. With these criteria in mind and with Newton's Laws to guide us, we can now try to meet these requirements.

How can the force of a body standing upon the floor, when there is no neuromuscular function below the lesion site, be harnessed in a manner so as to keep the body erect and balanced? To begin, we construct a firm, broad, flat platform, or foundation.

Fabrication

The sole of a well constructed welt-type shoe is removed so that a piece of spring steel, approximately ⅛ inch by one inch and shaped to the contour of the bottom of the shoe, can be embedded into the insole. The longitudinal plate should extend from the heel to a line one inch distal to the metatarsal head area (Fig. 1). A full sole of firm oak-tanned leather is placed over this longitudinal plate, sewn to the welt, and nailed to the heel. This

Fig. 4

View of the lower portion of the Scott-Craig Brace. In order to show construction details more clearly, this picture was taken before the anterior tibial band was added.

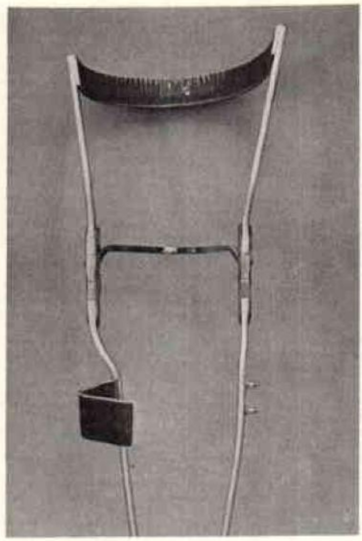

Fig. 5

View of the upper portion of the Scott-Craig Brace. Again the pads have been omitted in order to better show construction details.

arrangement contributes to antero-posterior stability.

To provide medio-lateral stability to the forepart of the foot, a piece of steel approximately 1/8 inch by 3/4 inch is embedded transversely across the entire sole at the metatarsal head area, and one rivet is placed centrally through the transverse plate, sole, longitudinal plate, and insole. To provide additional support in both planes, and to provide for the attachment of the ankle joints, a standard "Becker" type double Klenzak stirrup with a strut added is used (Fig. 2). The strut, formed from 1/8 inch by 1/2 inch coldrolled steel, is welded to both stirrup heads and to the distal shank of the stirrup. The modified strut is then riveted to the shoe sole. The two anterior rivets pass through the strut, sole, and insole, but span both edges of the longitudinal plate. No holes should be drilled through the longitudinal plate in this area, so as not to weaken the longitudinal plate in its highly stressed area. The middle and posterior rivets, though, pass centrally through the stirrup, sole, longitudinal plate, and insole (Fig. 2).

To further establish a flat, rigid platform, sole leather is cut and formed to fit over the stirrup-strut structure from the metatarsal head area line one inch from the posterior edge of the heel, tapered in such a manner as to provide for the necessary heel build-up (Fig. 3). The last inch of wedge build-up is made of a semifirm foam rubber that acts as a cushion at heel strike. The flat wedge-type sole provides both strength and stability. To finish off the sole, a piece of Neolite top soling, 1/8 inch thick, is glued over the entire sole.

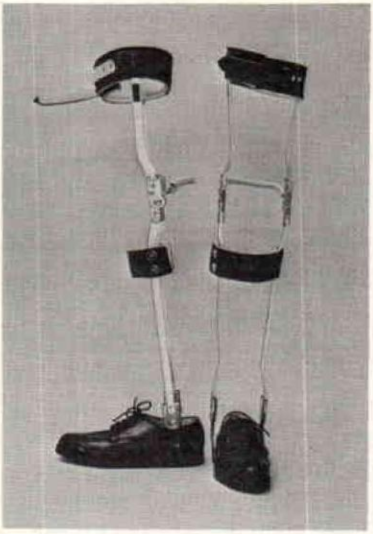

Fig. 6
The finished brace.

To provide some flexibility and adequate shoe-to-floor friction during heel strike and toe push-off, double Klenzak ankle joints are bolted to the stirrup heads (Fig. 4). The customary springs are replaced with solid rods so that by simply adjusting the cap screws upon the rods, the amount of ankle dorsiflexion required for the patient to obtain optimum control can be provided. All four cap screws must be secured tightly during each adjustment to eliminate the slightest amount of motions about the ankle joint.

The medial and lateral below-knee uprights are now cut from ¼ inch by ⅝ inch 2024 ST4 aluminum stock with a ⅝ inch posterior offset at the knee joint. The distal end of the uprights are riveted to the ankle joint and the proximal ends riveted to the lower half of the knee joints. A pre-tibial, hinged, half band consisting of a sturdy gate hinge and a piece of ⅛ inch by 1½ inch 2024 ST4 aluminum stock is riveted to the medial upright at a position immediately below the tibial tubercle (Fig. 5). No posterior cuff is necessary because all forces below the knees are applied anteriorly. Care must be taken to pre-shape the anterior band for relief over the tibial ridge. Two convertible automobile top fasteners are riveted to the lateral upright to provide ease of closure and unlatching after the cuff has been applied. The anterior tibial band must, of necessity, be shallow in order to keep the knee extended, and must be well contoured and padded in order to avoid excessive skin pressure. The above-knee medial and lateral bars are cut from ¼ inch by ⅝ inch 2024 ST4 aluminum stock, and riveted to the upper section of the "Becker" spring loaded, bale-lock knee joint. The knee joint is offset ⅝ inch posteriorly for two reasons: 1) the forces involved tend to keep the knee joint extended, thus allevi-

Fig. 7
Patient standing in the Scott-Craig Brace.

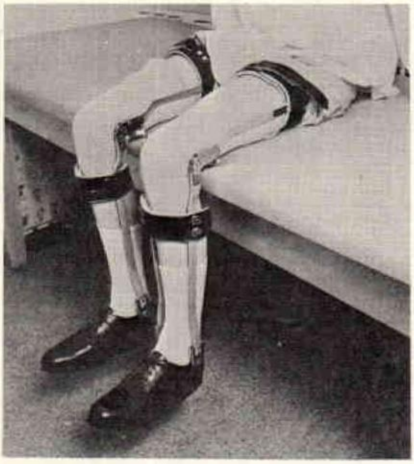

Fig. 8
Patient sitting while wearing the Scott-Craig Brace. Note the effects of the offset knee joints.

ating stress on the locking mechanism, and making it easier to unlock, and 2) there are no sharp, protruding edges when the knees are flexed during sitting, thus, saving wear and tear on trousers (Fig. 6).

The above-knee uprights are made shorter than is customary in order to allow freedom of hip joint hyperextension. In addition, use of the "shorter-than-usual" medial upright, when upper motor neurological involvement is present, lessens the possibility of pressure spasticity of the adductor longus muscle.

The proximal-posterior band is contoured to provide total contact and is more shallow than is customary. The proximal-posterior band, as well as the pretibial-anterior band, must be shallow enough so that the forces applied by the bands will hold the knee in full extension. A leather cuff covers the proximal posterior band and completely encircles the thigh. A one strap ring-slide, loop-back, Velcro closure is used.

Training

In a typical case, gait training starts approximately seven weeks post-injury with a Jewett-type hyperextension back brace, Scott-Craig long leg braces, and Canadian-type crutches. About six weeks later the Jewett brace is exchanged for a padded Hoke corset. In lower neurological lesions the corset is discontinued as soon as possible. The physical therapist determines the proper amount of dorsiflexion by altering the setting of the screws and length of the pins in the Klenzak ankle joints while the patient is standing in parallel bars, a procedure that requires a good deal of patience. When the proper amount of dorsiflexion is found, the patient stands relaxed and is able to maintain balance without arm support. A swing-through gait with Canadian-type crutches is taught as the therapist walks behind and pushes anteriorly at the hips to insure hip hyperextension at heel strike. A pelvic band is never required.

Wheelchair transfers are taught immediately. The knee joints are locked in extension, and the patient is taught to come straight out of the chair, with a postero-inferior force on each of the crutches, into a balanced, hyperextended stance. Sitting down is exactly the reverse, the bale locks becoming disengaged upon coming in contact with the anterior edge of the wheelchair seat.

When the patient has gained confidence in his ability to "walk" alone, training is given for negotiation of all types of terrain, ramps, curbs, stairs, etc. under various conditions, and for recovery after a fall. Swing-to, side steps, and turns are taught also. A four-point gait is demonstrated only to show that this technique is slow and requires more energy than is necessary.

Because balance is achieved easily parallel-bar work is eliminated, and gait training and expensive hospitalization time are reduced susbtantially. The average time for a typical case to "solo" is two weeks, and for complete training is four to six weeks. In addition the rapid physical progress is physchologically beneficial to the patient.

Prescription

Criteria for prescription are very simple. The upper extremities and shoulder girdle must be adequate for handling crutches, and motivation on the part of the individual to "have-a-go-at-it." The average patient, during his first six weeks post-injury, should be on a training frame in the gym doing exercises to strengthen the upper limbs and is usually motivated when he observes the progress of other patients who are further along in the program.

A Note of Caution

The apparent simplicity of the brace design must not lead one to believe that the fit and force factors are equally simple. To obtain application of the correct forces every step in fabrication must be strictly adhered to; otherwise, one must expect failure in structure, balance, mobilization, or combinations thereof.

A Note

A Super-8mm movie of gait training is available on loan from Craig Rehabilitation Hospital, 1599 Ingalls Street, Denver, Colorado 80214.

Acknowledgments

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Reference

1. Hahn, Harry R., Lower-extremity bracing in paraplegics with usage follow-up, Paraplegia, 8:3: 147-53, November 1970.