THE ABOVE-KNEE FRACTURE ORTHOSIS

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The Prosthetic and Orthotic Division of the University of Virginia with the cooperation of the Department of Orthopedics has conducted over the past eight months a limited investigation of the treatment of femoral fractures with a temporary orthosis made from prefabricated components and plaster of Paris. Until recently it had been generally held that the only suitable method for good osteosynthesis of fractures was rest and rigid fixation. If the fixation could not be achieved by external means, internal fixation would have to be accomplished. There has been good laboratory evidence showing the detrimental effect on healing of motion at the fracture site (5). However, it is well known that the clavicle and ribs heal very nicely while under fairly constant motion.

With this in mind, there were some advocates of early ambulation and weight-bearing on the fractured tibia. During the 1950s the United States Army conducted a study of this concept that resulted in the closed weight-bearing treatment becoming the one choice in the military (1). Sarmiento's work (6, 7) with the functional below-knee cast for tibial fractures that resulted in the development of the functional below-knee brace has now almost completely eliminated any need for open treatment of tibial fractures. The concept that the soft tissues of the leg act as a "fluid" and the ends of the fractured tibia are pistons within this "fluid" defines a hydraulic system (7): that is, when a snug-fitting cast or brace imposes definite boundaries on the soft tissue, the soft tissue then acts as a rigid cylinder when loaded. This rigid cylinder then is inherently stable and no appreciable shortening or displacement can occur. This principle has been proven adequately in the case of the tibia, and can also be applied to the femur.

The femur, however, poses a problem more difficult than the tibia. The thigh contains considerably more soft tissue than the tibia and has a much greater cross-sectional area at each end allowing the soft tissue to escape from the rigid cone that is formed by an enclosing cast or brace when the leg is loaded, thereby allowing some shortening. Furthermore, the femur is considerably more lateral to the line of force from the center of gravity of the body than is the tibia so that there is a greater force present to cause angulation. Consequently, treatment of the fractured femur while ambulation is permitted is not as satisfactory. Sarmiento has been somewhat disappointed with functional bracing of femoral fractures when compared to tibial fractures (7). Mooney *et al.* (4) have found that this form of treatment is superior to the conventional spica-cast treatment for distal femoral fractures.

The major difference in treating the two types of fractures is that in the femur some inherent stability of the fracture through healing must have taken place before ambulation is encouraged. This is accomplished by applying traction for a period of time sufficient to obtain stability, usually about seven weeks for adults. The best results occur when the distal half of the femur is involved. Fractures more proximal will angulate because of the impossibility of providing a cone of support high enough to counteract the natural tendency for lateral angulation. As in the case with the tibia, the cast about the thigh provides a truncated cone with the soft tissue becoming rigid when loaded. The addition of a quadrilateral-socket contour to the thigh piece provides some rotational stability.

Only the thigh portion of the orthosis is func-

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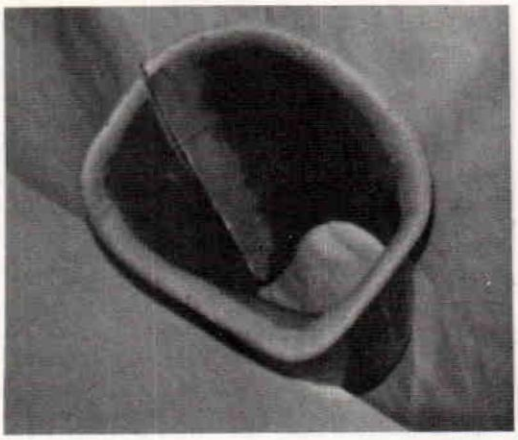

Fig. 1. Prefabricated plastic quadrilateral-type socket brim used to provide rotary stability about the thigh.

tional, the remainder of the orthosis being used only to hold the thigh portion in place. Most of these orthoses are supported from below by knee hinges attached to a cast about the shin or by a cable attached to the shoe. Deyerle (2) suspends the thigh piece from a waistband leaving knee and leg entirely free.

The use of the cast brace permits the patient to get out of bed and to leave the hospital sooner and in a more functional capacity than is the case when a spica cast is used. The risk of osteomyelitis from internal fixation is eliminated and the healing time is shortened. In a study by Mooney (4), the average time of treatment was 14.5 weeks compared to 24.7 weeks using spica casts.

This form of treatment can be used in children but should be restricted to those under the age

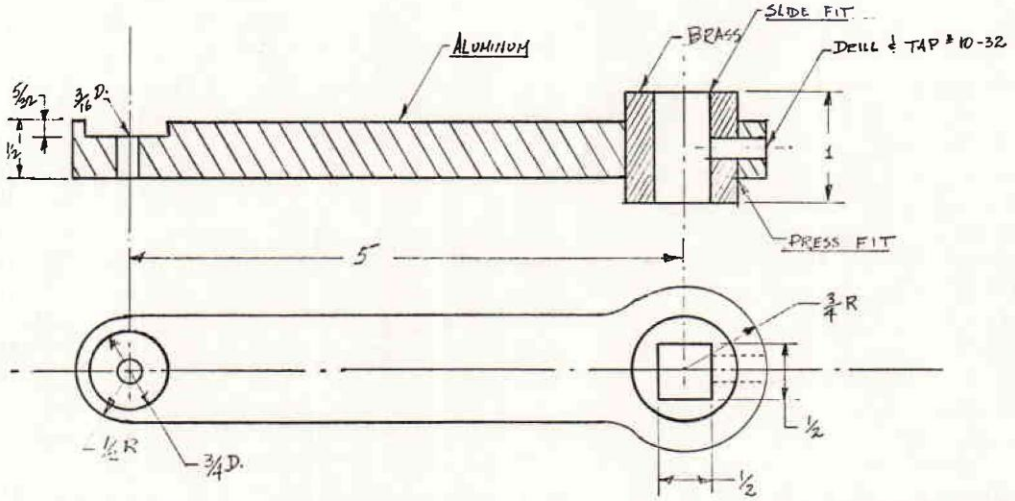

Fig. 2. Alignment fixture, upper left, and sketches of two of the major components. The connecting slide-bar is simply brass stock ½" × ½" about 13" long.

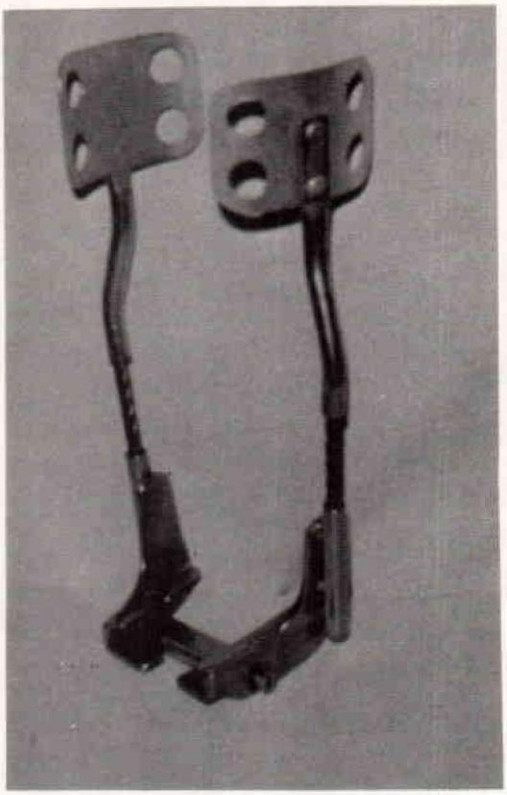

Fig. 3. Ankle "joint" developed at the University of Miami.

of ten with a well-contoured leg after at least four weeks of traction. If angulation is noted after ambulation it should be corrected, or it will progress (3).

THE TECHNIQUE

The orthosis is applied to the patient's limb after a period of traction to gain bony stability, usually about seven weeks. The design of the orthosis is intended to create a total-contact appliance that will give stability to the fractured femur. A quadrilateral-type socket brim is used to provide rotary stability about the long axis and a close fit about the thigh (Fig. 1). The orthosis is only intended to be partially weight-relieving.

Careful alignment of the knee joint is obtained by the use of an alignment fixture designed and fabricated by the Biomedical Engineering Department at the University of Virginia (Fig. 2). In most cases no ankle joint is used. However, when one is used, it is the one developed by Sinclair at the University of Miami (Fig. 3)[3].

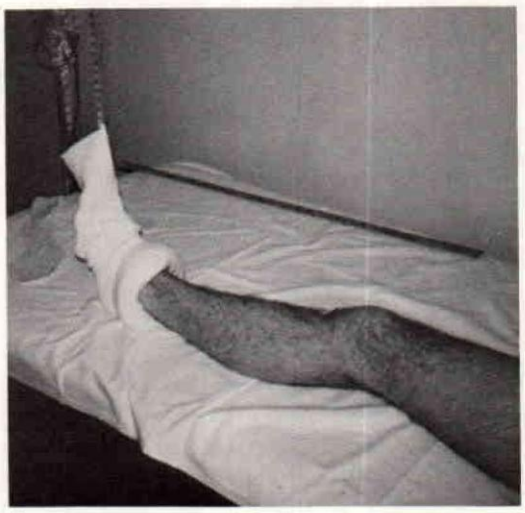

Fig. 4. Application of cast-fracture sock.

MATERIALS AND COMPONENTS NEEDED FOR APPLICATION

1. One cast-fracture sock[4]
2. One split quadrilateral socket
3. Five rolls, resin-impregnated plaster of Paris
4. Four rolls, elastic plaster of Paris
5. Two malleolar pads
6. One calcaneal pad
7. One pair of knee hinge joints
8. One alignment fixture (Fig. 2)
9. One can, medical adhesive
10. One fracture boot

APPLICATION OF THE ORTHOSIS

When traction is discontined the cast orthosis is applied to the patient in the following manner: a cast-fracture sock, a prefabricated, split, quadrilateral socket brim, and a pair of conventional orthotic knee joints with drop locks are selected, and the joints are prepared and attached to the alignment fixture. If an ankle joint is to be incorporated into the orthosis, it is also selected at this time.

After the traction equipment has been removed, the cast fracture sock is slipped over the patient's limb while he is still in bed (Fig. 4). He is then transferred to the fracture table.

[3]United States Manufacturing Co., Glendale, CA 91209

[4]Knit-Rite, Inc., Kansas City, MO 64106

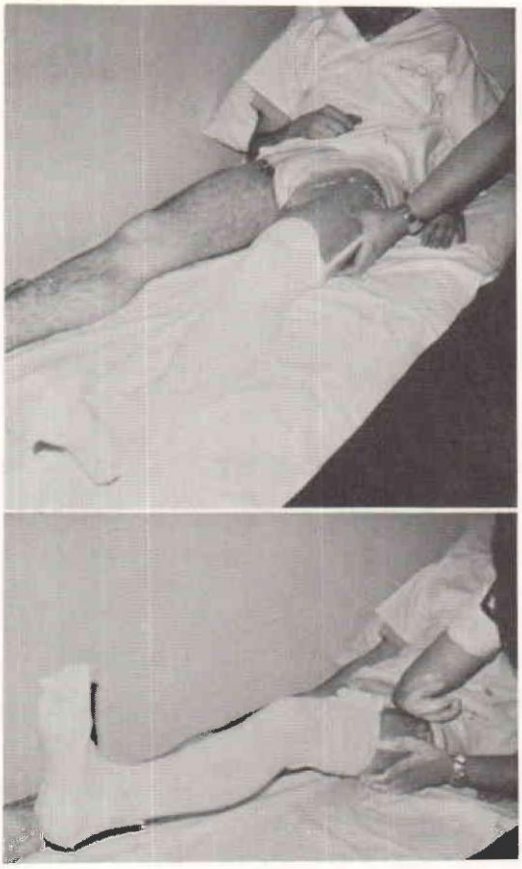

Fig. 5. Application of the quadrilateral-socket brim.

(The use of the fracture table is recommended because it allows the practitioner complete freedom to work around the limb. If a fracture table is not available, the procedure can be carried out on a bed or a stretcher.) The quadrilateral-socket brim is applied as high as possible on the thigh and is secured by two circular wraps of resin-impregnated plaster[5] (Fig. 5).

The practitioner must at this time make sure that the quadrilateral socket is providing total contact. The malleolar and calcaneal pads are applied, and the extremity is held with the knee in slight flexion and the ankle at 90° (Fig. 6) so that the cast sock adheres closely to the skin as the wrap is made.

Starting at the distal end of the quadrilateral socket, the limb is wrapped with elastic plaster-of-Paris bandages. Each wrap overlaps one half of the previous wrap. Use of elastic plaster bandage is essential to insure total contact. This wrap is carried all the way to the heel and toes.

[5]Merck, Sharp, and Dohme, West Point, PA 19486

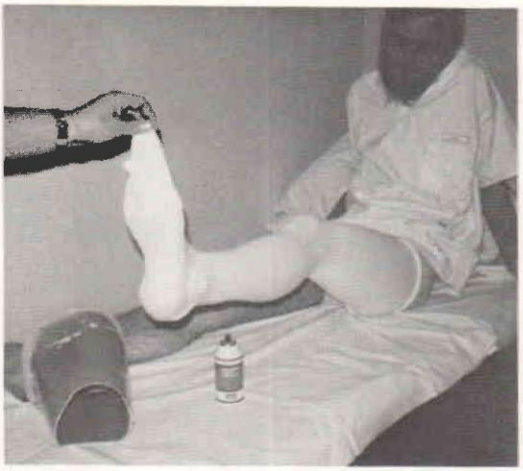

Fig. 6. Making sure that the cast sock adheres to the skin to, in turn, insure that total contact between cast and limb will be obtained.

Particular care must be given to the area surrounding the foot-ankle complex because the elastic plaster bandage will shrink as it hardens, and may cause excessive pressure in this area. After the elastic plaster has hardened, two layers of resin-impregnated plaster to provide adequate strength are applied starting at the most proximal section of the orthosis and carried all the way to the toes.

After the cast has hardened, rectangular sections on both the medial and lateral sides at the level of the knee are cut out of the cast (Fig. 7) and the knee joints are attached utilizing the

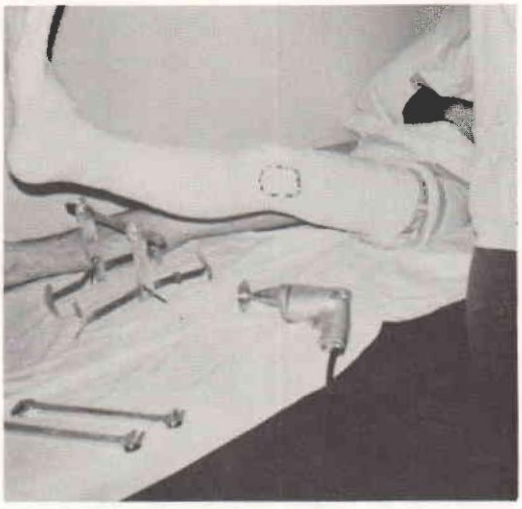

Fig. 7. Rectangular sections are cut out of the cast in the area corresponding to the knee joint.

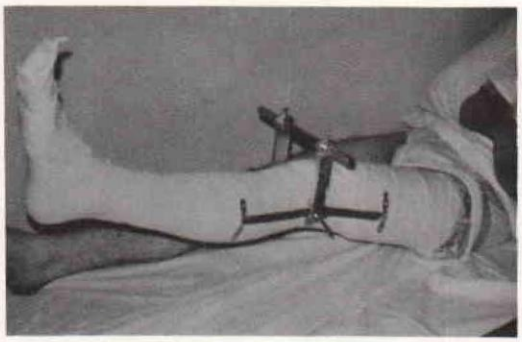

Fig. 8.Attachment of the knee joint by use of the alignment fixture (Fig. 2).

alignment fixture (Fig. 8). The axis of the knee hinge should be as close to the axis of the knee joint as possible.

After twenty-four hours, the patient may be allowed to bear partial weight with crutches using his orthosis (Fig. 9). After forty-eight hours the remainder of the knee section is removed to allow

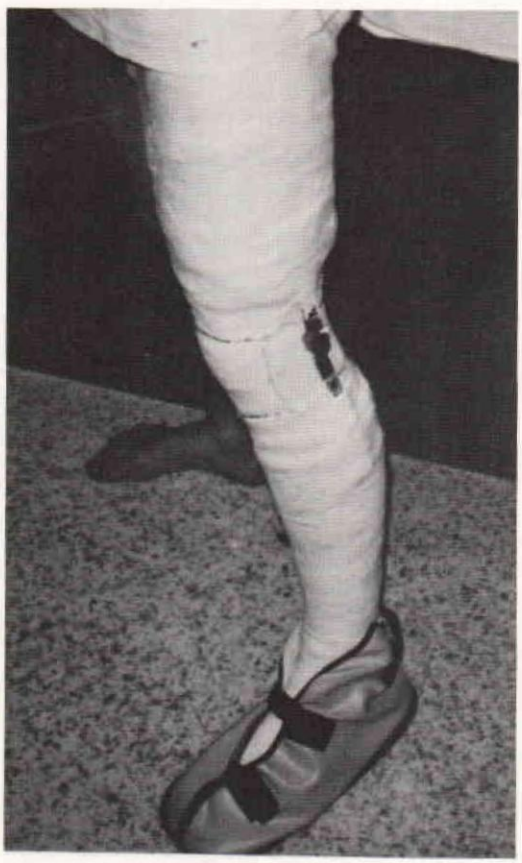

Fig. 9. Partial weight-bearing is generally allowed after 24 hours.

Fig. 10. View showing trim lines on proximal and distal portions of cast made approximately 48 hours after application.

knee motion (Fig. 10). The Orlon cast sock should not be cut because it helps to prevent edema around the knee.

At this time it is important to assure a good range of motion of the knee by cutting away plaster in the popliteal area if necessary. After two weeks of training with crutches, knee exercises, and cast adjustments for comfort, the patient usually may be discharged. The average patient will require no more than two to three months of use of his orthosis. After this time if X-ray and clinical signs show good healing, he may walk with crutches but without any other means of external support.

CONCLUSION

As stated previously, the ambulatory treatment of fractures of the femur with a cast orthosis is considered to be a reliable method. Our experience with more than 30 patients closely parallels that of Mooney (4). Shortening should remain the same as accepted during traction. Knee edema if present should disappear in a month's time; however, all patients should elevate the limb for approximately ten minutes each hour.

The indication for use of the cast orthosis is any patient with a fracture of the distal femur with a well-contoured thigh who has no other injury that would preclude ambulation. Contraindicated is the patient with a short obese thigh unless he has a very low fracture. Epiphyseal fractures should not be treated by weight bearing. If angulation is accepted during traction it will probably worsen in the fracture brace. This form of treatment allows the patient to get out of the hospital sooner and to better care for himself as well as shorten the overall healing time.

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