Application of Prosthetics-Orthotics Principles to Treatment of Fractures

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Greater knowledge and understanding of bioengineering by the prosthetics and orthotics industries during the past twenty years have resulted in the development of highly functional and sophisticated appliances. For example, modern prostheses for lower- and upper-extremity amputees are now designed with proper attention given to energy expenditures and other physiological factors based on scientific information obtained from laboratory and clinical studies. Close liaison between medical and engineering disciplines has contributed enormously to the revolutionary changes that prosthetics and orthotics have undergone during the past two decades.

Experience in the management of amputees has given the authors the opportunity to study the possibilities of utilizing prosthetics principles in the management of orthopaedic conditions. The first of these came as a result of clinical work with below-knee amputees. Prior to the development of the patellar-tendon-bearing (PTB) prosthesis in 1957, the below-knee amputee ambulated with an appliance which required a thigh corset to provide stability and to assist in the distribution of weight-bearing forces. The PTB prosthesis proved that the below-knee stump could take the pressures necessary for weight-bearing during ordinary activities without assistance from a thigh corset. The snug, total-contact fit and the firm contouring of the tibial flare and patellar tendon make possible weight-bearing ambulation without undue pressure being exerted over small areas or appreciable telescoping of the stump in the prosthesis.

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The traditional belief in orthopaedic circles has been that fractures of the tibia require the joints above and below the fracture site to be immobilized, the knee joint to be held in flexion to increase rotational stability, and weight-bearing to be avoided until fracture healing is complete. Some reports have appeared in the literature where ambulation on the fractured extremity is encouraged while the injured limb is stabilized in a groin-to-toe cast. This method, however, makes motion of the knee and ankle joints impossible *(1)*.

Convinced that the patellar-tendon-bearing prosthesis can adequately stabilize the stump without excessive piston action or rotation, the senior author applied the principles of this appliance to the treatment of tibial fractures. Three and a half years ago, he constructed a total-contact, below-knee cast firmly molded over the entire leg and contoured over the proximal tibia in a.manner identical to that of the patellar-tendon-bearing prosthesis (Fig. 1). The results were encouraging, since the fracture united without loss of the reduction originally obtained and without additional shortening, angulation, or rotation of the fragments. Since then we have treated 200 patients with various fractures of the tibia, malleoli, or os calcis (2).

The impossibility of providing flexion in the proximal segment of the cast, as in the case of the PTB prosthesis, soon convinced the authors that the patellar tendon was not a major contributor to the distribution of weight-bearing pressures. In most cases, we do provide the patellar-tendon indentation and high condylar wings because they appear to be valuable in enhancing rotational stability, particularly in cases of high tibial fractures.

With this short-leg, total-contact PTB-like cast, weight-bearing forces are transmitted

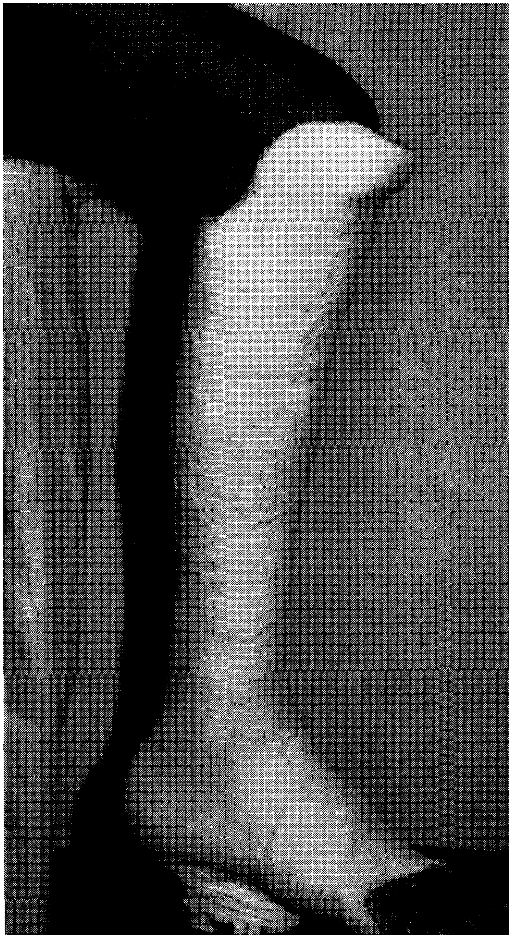

Fig. 1. Short-leg total-contact PTB-like cast for tibial fractures.

from the ground to the proximal tibia, virtually bypassing the fracture site. At first glance, such a method of treatment appears to conflict with orthopaedic principles. It is the authors' belief, however, that it utilizes to a fuller degree the knowledge of basic principles governing osteogenesis and fracture repair. The active use of the extremity in a near-normal manner seems to place the fractured limb in a physiological environment more conducive to uneventful healing.

Experience with the first 200 cases and the addition to the staff of the University of Miami School of Medicine of the junior author of this paper made it possible to attempt elimination of the foot and ankle portion of the cast, the object being the transmission of weight-bearing forces from the ground to the proximal tibia by means of metallic uprights attached distally to the patient's shoe and proximally to the cast (Figs. 2 and 3). We have treated 40 tibial fractures with this cast-brace with encouraging results.

In order to utilize the benefits of a near-normal physiological environment in fractured limbs, we have used short-leg, total-contact casts with or without the orthotic components in many instances of delayed unions with or without associated chronic osteomyelitis. A complete report on these cases will be published in the near future.

In the same manner that the patellar-tendon-bearing prosthesis led to the development of the short-leg, total-contact cast, we have introduced the principles of the quadrilateral, ischial weight-bearing prosthesis to the treatment of fractured femurs. We have con-

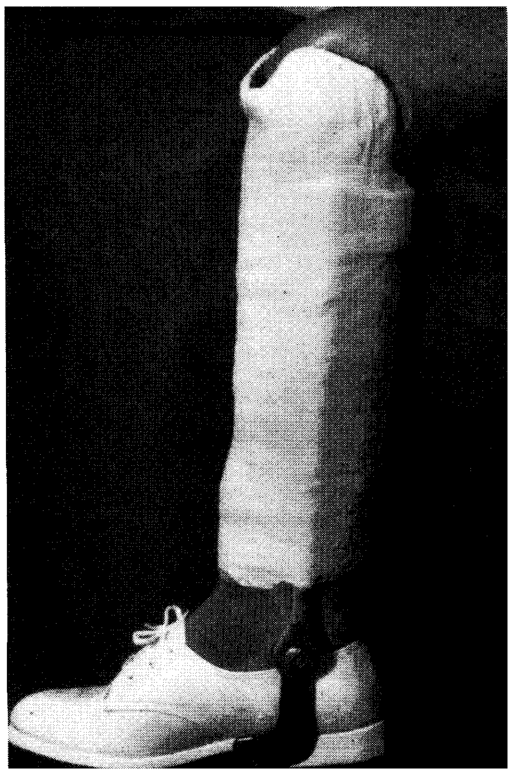

Fig. 2. Short-leg total-contact cast-brace used in the treatment of tibial fractures.

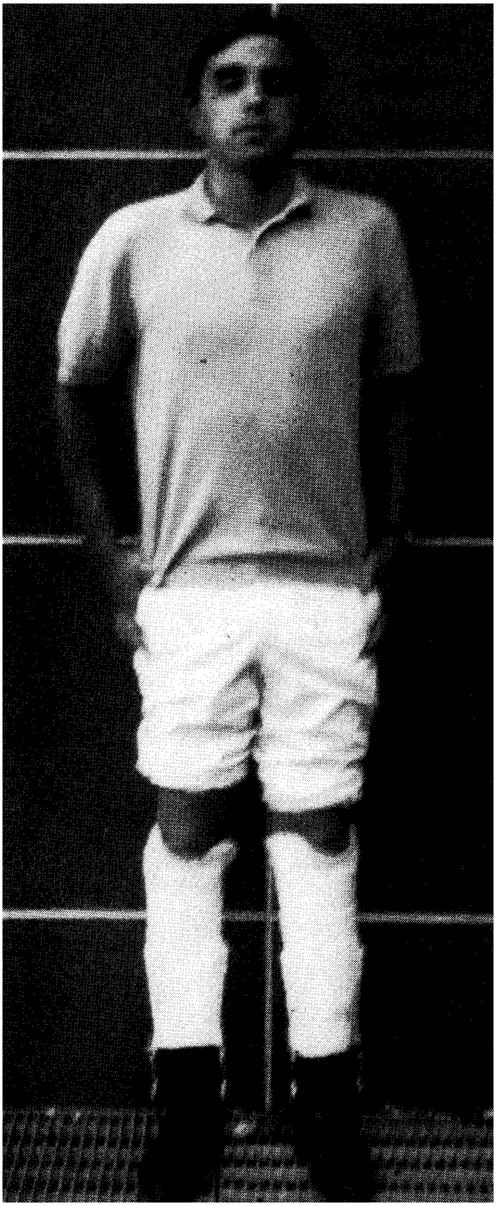

Fig. 3. Bilateral short-leg total-contact cast-braces used in delayed union of tibial fractures.

structed a cast-brace that stabilizes the fractured femur but permits freedom of motion of the hip, knee, and ankle joints (Fig. 4).

This cast-brace is applied with the patient standing on his normal limb while the ischium on the affected side rests on the platform of an above-knee casting stand. Ambulation results in transmission of weight-bearing pressures from the ground to the ischium, thus preventing shortening of the fractured fragments, angulation, and rotation. Our experience has been limited, and so we are in no position at this time to state whether or not this cast-brace will earn a place in the armamentarium of the orthopaedic surgeon.

We have utilized the basic construction design of the Munster prosthesis as applied to the very short below-elbow amputee, and have constructed a cast in a manner similar to that of this prosthesis. To prevent rotation of the forearm, the cast is molded in such a manner that its anteroposterior diameter is as narrow

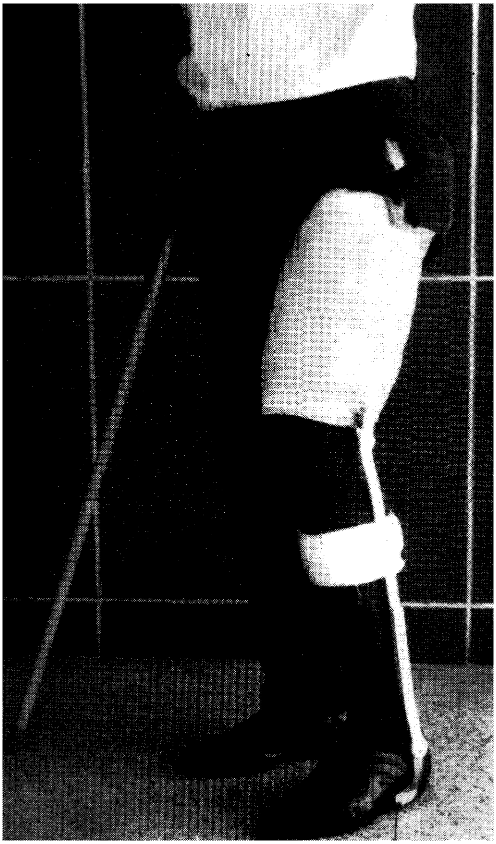

Fig. 4. Ischial weight-bearing cast-brace for femoral fractures.

Fig. 5. Cast-brace with articulated wrist joint for forearm fractures.

as possible. The high condylar wings firmly contoured over and around the bony prominences of the forearm and humerus enhance rotational stability. A metal joint makes possible freedom of motion of the wrist joint (Fig. 5).

The possible applications of these cast-braces may be numerous in the everyday practice of orthopaedics. Additional investigations should be conducted before arriving at any final conclusions regarding the value of these approaches.

CONCLUSION

Familiarity with prosthetic appliances has resulted in the application of their basic principles to the management of orthopaedic conditions of the upper and lower extremities.

A functional short-leg, total-contact cast based on the patellar-tendon-bearing (PTB) prosthesis was developed and used in 200 cases of tibial, malleolar, and os calcis fractures. In addition, a short-leg, total-contact cast-brace which permits motion of the knee and ankle joint has been utilized in 40 cases of fresh and old tibial fractures.

Attempts have also been made to stabilize femoral and forearm fractures with cast-brace appliances. These cast-braces are constructed with features resembling those of the ischial weight-bearing quadrilateral socket and the

Miinster prostheses used by above-knee and below-elbow amputees, respectively.

There are many clinical situations in orthopaedics which provide opportunities for further study of the utilization of prosthetics-orthotics principles.

LITERATURE CITED

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