CAST-BRACING OF FEMORAL FRACTURES
EXPERIENCE AT EMMORY UNIVERSITY HOSPITALS

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ABSTRACT: At Emory University Hospitals from 1975 to 1979, 110 fractures of the femoral shaft were treated following a femoral fracture protocol with a single component cast-brace and early ambulation. In an effort to reduce the hospitalization and disability time in patients with mid-third and distal-third femoral fractures, a technique of modified Dehne bracing was used in which immediate ambulation was instituted after casting. Prior to initiation of this protocol, these fractures were routinely treated with six to eight weeks of balanced traction, followed by four to six months of cast fixation and a subsequent period of rehabilitation. Complications of the technique occurred in 9% of the patients, with shortening of 2.3 cm in 5%, refractures in 3% and malunion in 1%.

This series of patients demonstrates the technical feasibility of a single component cast-brace and early ambulation for fractures of the femoral shaft, which is a great advance in the closed treatment of femoral fractures. Our results show that early cast-bracing using a modified Dehne technique is a viable method of treating fractures of the femoral shaft, with the technique being most effective when applied in the early stages—days one through 28. Indexing terms: cast-bracing, femoral fractures.

Introduction

As early as 1910, Champonierre advocated early ambulation and weight-bearing of fractured tibia in plaster casts. Forty years later, Charnley demonstrated that the degree of joint motion is in direct proportion to the speed of union. Dehne later documented that early ambulation in a long leg cast-brace resulted in early union without complications in tibial shaft fractures. He surmised that rigid immobilization was no longer necessary for the healing of fractures in long bones, and that early introduction of motion favored osteogenesis, while preventing joint stiffness and muscle atrophy. Sarmiento and Brown and Urban have also reported excellent results in patients treated with early ambulation and appropriately applied plaster casts for tibial shaft fractures. Sarmiento proposed that the soft tissues of the extremities, when enclosed in a splint brace, behave mechanically as fluids, essentially incompressible, exerting lateral and oblique forces that offset the vertical loads of ambulation, effectively preventing shortening and maintaining alignment.

In 1970, Mooney extended the concept of ambulatory treatment with cast-braces that Dehne, Sarmiento, and Brown and Urban had demonstrated for tibial shaft fractures. Mooney proposed that the most important factor for rapid and efficient fracture healing is an environment of function for the healing fracture, permitting continuing muscle and joint function, but at the same time protecting the fracture from destructive forces. Connolly et al. reviewed a large series of femoral fractures treated by early cast-bracing, most prior to four weeks, with very encouraging results. More recently, Mckibbin documented that external callus is the most rapid of all the fracture healing processes and the one that normally predominates in fractures treated with cast immobilization. He considered speed its greatest advantage, and stated that the clinical evidence showed that this process is the quickest way to restore the strength of the fracture diaphysis to its
former level. Similarly, Hardy et al. and Wardlaw et al. recently reported excellent results in the treatment of femoral shaft fractures by cast-bracing and early walking. Wardlaw et al. measured the off-loading characteristics of cast-braces in 30 patients with femoral shaft fractures, and found that the cast-brace provided an environment in which alignment of the fracture was maintained with longitudinal, rotary and angular stesses limited. Thus, they concluded that the femoral fracture cast-brace provides an optimal environment in which union is stimulated and rehabilitation is permitted while the fracture is uniting.

The purpose of this paper is to report our experience with a technique of femoral fracture cast-bracing in which the cast is applied as a single unit, with a specific emphasis on cast application within the first four weeks after injury.

Materials and Methods

This series consists of 109 patients with 110 fractures of the femoral shaft treated by cast-bracing at Emory University Hospitals over a five-year period (1975 to 1979). Cast-bracing with early ambulation was used to treat 71 mid-third and distal-third femoral shaft fractures from 1975 to 1977. However, from 1978 to 1979, after the introduction of closed intramedullary nailing in our institutions, cast-bracing was used to treat either femoral shaft fractures unsuitable for closed intramedullary nailing (Winquist Grade IV comminuted fractures with loss of cortical continuity) or fractures where the patient refused surgical intervention. Thus, 39 selected femoral shaft fractures were treated by cast-bracing from 1978 to 1979.

The cast-brace treatment of these 110 femoral fractures was evaluated both retrospectively and prospectively. Significant data recorded included: cause and location of fracture, time to casting, time in hospital, time in cast-brace, time healing and complications. There were 93 men and 26 women, aged 15 to 82, with a median age of 34. In this urban population, the predominant fracture etiologies were motor vehicle accidents (53), trauma from falls (32), and gunshot wounds (22).

Sixty-eight fractures were closed and 42 were open, with 57 involving the right femur and 53 involving the left femur. The 42 open fractures were further categorized according to Gustilo and Anderson’s classification. There were four Type I fractures, 10 Type II fractures and 28 Type III fractures. The majority of open fractures were Gustilo-Anderson Type III open fractures, that is, open fractures with soft tissue damage or open fractures secondary to a gunshot wound.

Ten fractures involved the proximal third of the femoral shaft, 62 the middle third, and 38 the distal third. The fractures were further categorized as either transverse (21), oblique (41) or comminuted (48). None were segmental. These characteristics are cross-tabulated in Table 1. Although cast-bracing was used primarily for fractures of the middle and distal diaphysis of the femur, the technique was also applied to a limited number (10) of severely comminuted or open fractures of the proximal femoral shaft, especially those secondary to shotgun wounds.

Technique

The technique of cast-bracing and early ambulation for femoral shaft fractures was instituted at Emory University Hospitals in 1975. The cast-brace is applied as a one component cylinder or long leg cast, and not in separate thigh and short leg components.

Upon admission to the emergency room, roentgenograms are made in the AP and lateral planes with the fracture charted as to type, location and degree of comminution. Open fractures receive essentially the same treatment as closed ones after copious irrigation and debridement with the wounds left open for delayed primary closure at five to seven days. Broad spectrum intravenous antibiotics are also initiated on admission.

After roentgenographic documentation of the fracture location and degree of comminution, a threaded pin of 7/64 inches diameter is drilled in the proximal tibia with subsequent application of a McCarthy traction bow. The patient is then sedated with diazepam and/or narcotics, and balanced skeletal traction is applied with the fracture pulled to length and reduced. Reduction usually requires 40 pounds of

<table>
<thead>
<tr>
<th>Fracture Type</th>
<th>Proximal third</th>
<th>Middle third</th>
<th>Distal third</th>
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<tr>
<td>Transverse</td>
<td>0</td>
<td>11</td>
<td>10</td>
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<tr>
<td>Oblique</td>
<td>0</td>
<td>25</td>
<td>16</td>
</tr>
<tr>
<td>Comminuted</td>
<td>10</td>
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<td>12</td>
</tr>
<tr>
<td>Closed</td>
<td>0</td>
<td>41</td>
<td>27</td>
</tr>
<tr>
<td>Open</td>
<td>10</td>
<td>21</td>
<td>11</td>
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Fig. 1A: The cast is marked over the patella with two triangles also marked medially and laterally to the anterior joint line.

Fig. 1B: The triangles have been removed with the cast saw to facilitate application of the knee hinges.
traction weight in men and 30 pounds in women. In general the fracture is easily reduced, with the reduction documented by AP and lateral roentgenograms. The lateral roentgenogram verifies that the fracture has been pulled to length. If the fracture fragments are overlapping, additional traction weight is applied. The patient is maintained in balanced skeletal traction until application of the cast-brace.

Minimal special equipment is necessary for application of the femoral fracture cast-brace. The following materials are needed: one spandex cast-sock, two 4" and four 6" rolls of standard plaster, one set of polyethylene multicentric accordion hinges, and two 2" rolls of plaster for application of the hinges. The brace may be applied in the patient’s room, the emergency room or the cast room.

Two operators are required to apply the cast. The spandex sock is rolled onto the leg with no added felt or elastic material over the knee. A long leg or cylinder cast is then applied directly over the spandex sock with the leg abducted and traction maintained. The tibial traction pin is incorporated into the plaster cast, preventing downward displacement of the cylinder cast-brace and permitting free ankle motion. However, in patients with large thighs, the foot is incorporated into the cast.

It is essential that the cast be applied as far proximally as possible to control rotation of the proximal fracture fragment. It is also essential to mold the fracture out of recurvatum with the fracture overcorrected into approximately 10° of anterior bow and as much as 10° to 15° of valgus. In our experience, postcasting roentgenograms demonstrate that with this mold, the fracture alignment reverts to neutral or slight valgus upon weight-bearing. In fractures of the proximal shaft a pelvic band is added to the cast-brace. The patient is placed at bed rest in longitudinal skeletal traction for 24 hours to allow for drying of the cast.

After the cast has been allowed to dry, attention is focused on the knee joint. The cast is marked directly over the patella with two triangles marked medially and laterally to the anterior joint line. The triangles are then removed with the cast saw to facilitate application of the knee hinges (Fig. 1). It should be emphasized that no special alignment devices are necessary for application of the knee hinges. The plastic accordion multicentric hinges are applied to the cast with two 2" rolls of plaster at the midportion of the patella, approximately 3⁄4" posterior to the midline of the leg. This placement is important to insure proper dynamics of the knee joint (Fig. 2).
Twenty-four hours after application of the cast-brace, physical therapy is initiated, with the patient beginning ambulation with the parallel bars progressing to crutch-assisted ambulation weight-bearing as tolerated. On postcast day one, the patient is also instructed in quadriceps exercises, initially assisted graduating to unassisted. When the patient demonstrates control of quadriceps function by independently performing 10 unassisted straight leg raises, the knee is cut free anteriorly and posteriorly and range of motion exercises are initiated (Fig. 3).

The patient is allowed up all day but placed back in straight skeletal traction at night. The traction weight usually must be increased 10 pounds more than the reduction weight to maintain length. Leg length roentgenograms are taken both in traction and standing weight-bearing. Films are taken in traction in the morning hours for comparison with standing
weight-bearing films at postcast days one, five, 10 and 15 to ensure that the reduction has been maintained. The tibial crest traction pin is removed and the patient is discharged when there is no roentgenographic difference between night traction and day standing leg lengths. The cast-brace is removed when there is both roentgenographic and clinical evidence that the fracture has healed. The fracture is considered healed clinically when the patient can tolerate full weight-bearing on the extremity without support and demonstrates no limp or pain. Healing is determined roentgenographically by obliteration of the fracture site with adequate callus formation and consolidation.

**Results**

All fractures healed. Followup ranged from two to six years, with a mean of 4.3 years. Five patients were lost to followup. Knee range-of-motion and rotational alignment were recorded one year after injury.

The period of hospitalization ranged from four to 142 days, with a mean of 39 days. The healing time, that is, the interval between injury and clinical and roentgenographic healing, ranged from 87 to 292 days, with a mean of 125.7 days.

Shortening was determined by leg length roentgenograms. The mean amount of shortening in this series was 1.1 cm. Fifty-six patients had shortening greater than 1 cm; however, in these 56 patients, we only encountered significant shortening (greater than 2 cm) in six patients. Excluding one instance where shortening was attributed to bone loss secondary to injury, we found the average amount of shortening for the other five patients to be 2.3 cm. Angulation was considered significant if it was greater than 10°. Twenty-three patients required an open wedge of the cast to correct angulation. Subsequently, three patients had varus angulation greater than 10°. Two of these patients suffered refractures, and the third one required open reduction and internal fixation to correct the malunion. All patients regained knee motion within 10° of normal. We noted no infections, pressure sores or neurologic damage resultant from the brace.

**Discussion**

In this series of femoral fractures seen in an urban population, motor vehicle accidents, gunshot wounds and trauma from falls were the predominant fracture etiologies. Although the cast-brace treatment was used primarily for fractures of the middle and distal diaphysis of the femur, we also applied this treatment to severely comminuted or open fractures of the proximal femoral shaft, especially those secondary to gunshot wounds.

The mean amount of shortening in this series was 1.1 cm. Shortening was greater than 2 cm in six patients. Hardy et al. found the highest incidence of femoral shortening occurred in those patients who had a cast-brace applied within the first two weeks after injury, with the second highest incidence of femoral shortening occurring in those patients who had a cast-brace applied six weeks or more from the time of injury. They suggested that the best time to apply a femoral cast-brace is the third week after injury. However, within the last year we have reduced our incidence of femoral shortening by placing the patient in balanced skeletal traction immediately upon admission to assure that fracture reduction and length have been attained. The cast-brace is then applied within the first four weeks after fracture, with minimal resultant shortening. Connolly et al. in support of the cast-brace treatment of femoral fractures, stated that closed reduction in a cast-brace provides both the relative safety of nonoperative treatment and the advantages of early mobilization made possible by internal fixation. They reported that 63 of 110 femoral fractures cast-braced within four weeks of injury healed by 14 weeks, with the remainder healing within six months after injury. Lesin et al. found that 26 femoral fractures treated with early cast-bracing (average of 9.3 days to bracing), the hospitalization and healing times were 28.9 days and 82.4 days respectively, with one complication of nonunion. Weiss employed the cast-brace technique of treatment in 34 nonoperative patients who presented with fractures of the distal portion of the femur. In his series, the mean hospital stay was 35.5 days, with 4.7 months to full weight-bearing. No complications were noted. Recently, Montgomery et al. demonstrated good results in treating femoral shaft fractures with roller traction and early ambulation.

In conclusion, this series of patients demonstrates the technical feasibility of a single component cast-brace and early ambulation for fractures of the femoral shaft.

**References**

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