Acta Orthop Scand 2002; 73 (1): 72–76

Supracondylar femur fracture fixation

Mechanical comparison of the 95° condylar side plate and screw versus 95° angled blade plate

Juha I Jaakkola[1], Douglas W Lundy[2], Thomas Moore[3], Brad Jones[1],
Timothy M Ganey[1] and William C Hutton[4]

[1]Department of Orthopaedic Surgery, Atlanta Medical Center, Atlanta, GA, USA, [2]Orthopaedic Center of the Rockies, Fort Collins, CO, USA, [3]Peachtree Orthopaedic Clinic, Atlanta, GA, USA, [4]Department of Orthopaedics, Emory University and Veterans Affairs Medical Center, 2165 North Decatur Road, Decatur, GA 30033, USA. Correspondence: Dr. William C. Hutton. E-mail: william_hutton@emory.org

Submitted 00-08-29. Accepted 01-06-15

ABSTRACT – The best way to stabilize supracondylar femur fractures remains debatable. Previous studies have compared internal fixation to intramedullary fixation, but none have compared the stiffness characteristics and strength of the 95° angled blade plate (ABP) with the 95° condylar side plate and screw (DCS). 14 synthetic femora were cut in half and the proximal pole of the distal fragment was made secure. A 1 cm gap was made parallel to the femoral condylar weight-bearing surface to create an extraarticular supracondylar femur fracture (OTA 33-A3). 7 femora were stabilized with an ABP and 7 with a DCS. Using an MTS compression/torsion servohydraulic testing machine, each femur was tested in 7 modes of loading: (1) axial compression; (2) anterior compression; (3) posterior compression; (4) medial compression; (5) lateral compression; (6) torsion in external rotation; and (7) torsion in internal rotation. The stiffness of the construct in each mode, the "maximum load in axial compression", and the fatigue characteristics in axial compression were measured. The DCS showed a statistically significant greater stiffness in axial compression and average maximal load than the ABP. The fatigue tests revealed no evidence of permanent deformation or loosening of either construct.

■

Various implants have been used for internal fixation of supracondylar femur fractures, including condylar buttress plating (Sanders et al. 1991), Rush-pin fixation (Shelbourne and Brueckmann 1982), antegrade flexible intramedullary Enders rodding (Moehring 1988), retrograde intramedullary nailing (Lueng et al. 1991), 95° angle blade plate fixation (Siliski et al. 1989, Merchan et al. 1992), and 95° condylar side plate and screw (Prichett 1982, Sanders et al. 1989). However, there is no consensus as to which method of internal fixation is the best.

Recently, Albert (1997) found that the 95° angle blade plate (ABP) was "the most secure fixation of the distal fragment". This statement is supported by a mechanical study which showed that the ABP is stiffer in torsion and A/P bending than a Green Seligson Henry nail (GSHN; Smith & Nephew Richards, Memphis, TN) and a retrograde intramedullary unreamed supracondylar nail (Synthes AG, Chur, Switzerland) (Ito et al. 1998). Related mechanical studies comparing the 95° condylar side plate and screw (DCS) with both antegrade and retrograde nails have produced conflicting results (Firoozbakhsh et al. 1995, Koval et al. 1996, David et al. 1997). Despite several such biomechanical and mechanical studies, none have made a mechanical comparison between the DCS and the ABP.

We compared the mechanical stiffness and strength of the ABP with the DCS in fracture stabilization of extraarticular supracondylar femur fractures. We chose to compare these two constructs because they are currently the most commonly used methods of plate fixation for supracondylar femur fractures.

Copyright © Taylor & Francis *2002. ISSN 0001–6470. Printed in Sweden – all rights reserved.*

Material and methods

14 synthetic femora (Type 3106, Pacific Research Laboratories, Vashon, WA), each designed to simulate the mechanical stiffness properties of human femora, were made. The femora were cut in half at the midshaft, but the 23 cm long distal fragment was retained. The proximal end of the distal fragment was secured in a plastic pot using calcium sulfate plaster (i.e., dental plaster). The distal fragment was placed in the pot so that the femoral condylar weight-bearing surface was parallel to the floor.

The appropriate-sized implants (ABP or DCS) were determined by using the Synthes templates (Synthes USA, Paoli, PA) on radiographs of an intact synthetic femur. The ABP selected had a 70 mm blade with seven holes (stock number 237.74) and the DCS was a six-hole plate (stock number 281.96) with a 70 mm lag screw (stock number 280.70S) (Synthes USA, Paoli, PA). The constructs were chosen to permit two points of fixation in the distal fragment and four screws (eight cortices) in the proximal fragment, as recommended in the AO Manual (Müller et al. 1995).

The femora were prepared for the ABP or the DCS before making the osteotomy cut. 7 femora chosen for the ABP group were prepared for the blade by making a channel into the anterior portion of the femoral condyle with a chisel. The blade plate was then inserted according to the AO Manual (Müller et al. 1995). The other seven femora chosen for the DCS were prepared with a lag screw and side plate in line with the manufacturer's specifications (Paoli, PA: Synthes, USA). A cancellous bone screw 65 mm long and 6.5 mm in diameter, with a 32 mm long thread (stock number 217.065), was then inserted through the distal hole in both implants. Eventually, this "derotation screw" would be put through the plate into the distal fragment in both constructs. The next hole was left unfilled, as this coincided with the osteotomy site; this compares to the clinical setting when faced with extensive comminution. The four remaining proximal holes had 4.5-mm diameter cortical screws inserted through both cortices. The most proximal hole in the ABP was left unfilled in order to have an equal number of screws in both constructs. The screws in the constructs were then loosened to allow easy access to the femoral shaft so as to perform the osteotomy. The osteotomy was cut by the method described by Ito et al. (1998). A metaphyseal complex extraarticular supracondylar femoral fracture (OTA Classification 33-A3) was simulated by making two parallel cuts 6.5 cm and 7.5 cm proximal to the distal femoral joint surface, and parallel to the knee axis (Figure 1). The implants were then retightened to secure them to the femora. Anteroposterior radiographs were taken to ensure proper placement of the implants (Figure 2).

Loading routine

A 6.25 mm thick, cross-shaped, metal loading-plate, with each arm 15 cm long, was constructed. Two 9.5 mm diameter screw holes were placed 2.5 cm on either side of the center of the loading-plate (i.e., 5 cm apart). Two holes were drilled into the femur with a 5 mm diameter drill bit at points 18 mm and 68 mm (i.e., 5 cm apart) from the medial edge of the medial condyle and 3.4 mm anterior to the posterior edge of the posterior condyles. The loading-plate was then screwed to the distal end of the femur using two 6.25 mm diameter wood screws. The same points were used on each femur to ensure consistency. Thus the center of the loading-plate approximated the central axis of the femoral shaft in the coronal plane and the central portion of the condyles in the sagittal plane.

Each femur, in its plastic pot, was then clamped to the base of an MTS 858 servohydraulic (compression/torsion) testing machine (MTS Systems Corporation, Minneapolis, MN) (Figure 3). Each femur was tested in seven modes of loading: (1) axial compression; (2) anterior compression; (3) posterior compression; (4) medial compression; (5) lateral compression; (6) torsion in external rotation; and (7) torsion in internal rotation. We applied medial, lateral, anterior, and posterior compression to the surface of the loading-plate at points 4 cm medial, lateral, anterior, and then posterior to the center of the loading-plate. Axial compression was applied through the center of the loading-plate (i.e., the central axis of the intramedullary canal). External and internal torsion (without compression) were carried out by locking the loading-plate to the actuator ram of the testing machine and then applying torsion through the ram. The center of

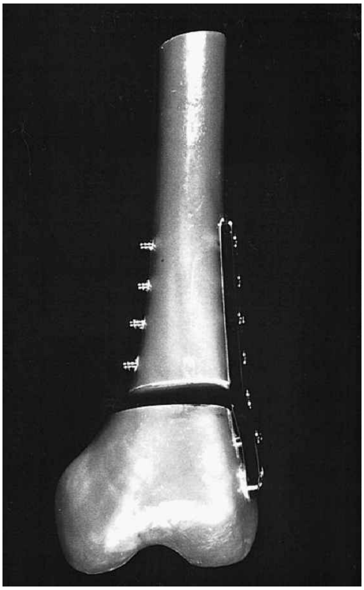

Figure 1. Photograph of the Synthes dynamic condylar side plate and screw-femur construct.

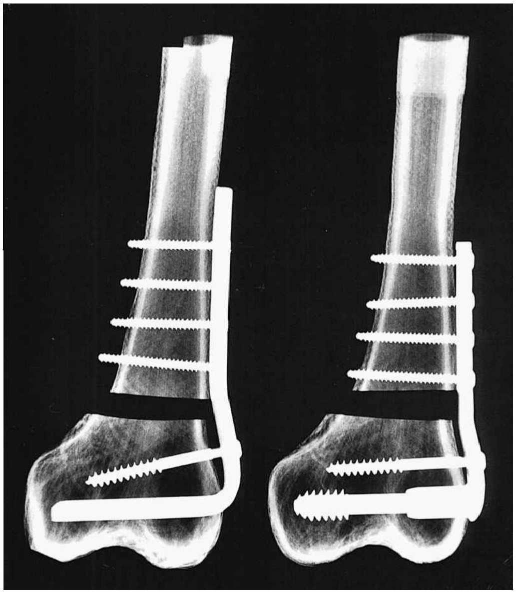

Figure 2. Radiograph of a Synthes dynamic condylar side plate and screw-femur construct and a 95º angled blade plate-femur construct.

rotation for torsion was the central axis of the intramedullary canal.

The sequence of testing was done in a random pattern to prevent a test ordering effect. Axial, medial, lateral, anterior, and posterior compression were done up to 360 N at a displacement rate of 100 cm/min. This compressive force was chosen to approximate half of the body weight of a 70 kg man. Torsion was applied through the plate to 25 Nm at a rate of 5 degrees/sec. A load-deformation curve was plotted for each of the seven modes of loading. We also measured the change in the angulation of the joint line at 360 N while testing at medial, anterior, and posterior compression. This was done with an electronic goniometer placed on top of the loading-plate. The femur plus construct were too stiff in lateral compression to show much angulation.

The slope of the load-deformation curve determined the stiffness of the construct in each mode of loading. Each test was repeated three times. There was little variation between each of the three tests. At the end of the experiment, the “maximum load in axial compression”, defined as the axial compressive load (applied at 10 cm/min) at which the medial cortices of the osteotomy came into contact, was measured. This load could be determined by

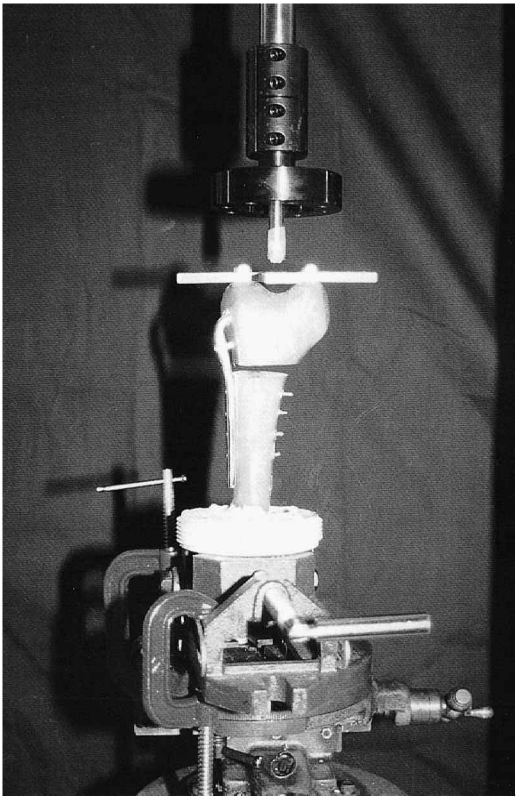

Figure 3. ABP construct mounted on a MTS servohydraulic testing machine.

Average stiffness (standard deviations) and p values for comparisons between the two types of instrumented femurs (DCS and ABP)

Construct	Compression (N/mm)					Torsion (Nm/°)		Maximum load (N)
	axial	anterior	posterior	medial	lateral	external rotation	internal rotation	
DCS (AVG)	375 (39)	149 (31)	165 (20)	1,047 (262)	108 (14)	5.5 (0.3)	5.2 (0.5)	2,532
ABP (AVG)	331 (32)	186 (41)	160 (29)	1,112 (289)	94 (12)	5.8 (0.5)	5.3 (0.8)	2,151
P-value	0.04	0.09	0.7	0.7	0.06	0.23	0.8	< 0.001

inspection and interpreted by observation of a significant change in the slope on the load-deformation curve as the medial cortices came into effect.

After stiffness testing had been carried out, two randomly selected femoral constructs from each group were cycled in fatigue. This fatigue testing was performed in axial compression at 1500 (SD 500) N at a rate of 1 Hz, to 80,000 cycles.

Statistics

The stiffness values, the angulation of the joint line, and the maximal load values were tabulated and averaged (Table). The measurements were analyzed using a t-test for independent group analysis of the mean values to determine statistical significance.

Results

The average stiffness values (SD) for the two constructs are given in the Table. The only significant difference was in axial compression. The average axial compressive stiffness of the DCS was 12% more than the ABP.

The average maximal load of the DCS was 15% greater than the ABP, which was a statistical difference. Although all plates showed some degree of permanent deformation in the area of the osteotomy, none had failed or loosened. During axial loading, the side plate of both constructs bent at the site of the osteotomy. Four femurs, two from each group, were tested for fatigue failure. Despite loading up to 80,000 cycles, none of the constructs failed or showed evidence of permanent deformation.

The angulation of the joint line at 360 N in medial, anterior, and posterior compression using the digital goniometer revealed no real difference (let alone a significant difference) between the two constructs. The results of these angulations are not given.

Discussion

Several authors prefer the DCS to the ABP for internal fixation of supracondylar femur fractures, largely because of the relative ease of insertion (Sanders et al. 1989, Merchan et al. 1992, Schatzker 1998). The ABP requires precise placement of the seating chisel in the anterior portion of the femoral condyle to allow satisfactory axial and rotational alignment. When the chisel is inserted, any malalignment, especially rotation in the sagittal plane, is difficult to correct. In a review of 42 closed, displaced supracondylar and intercondylar fractures treated with an ABP, Merchan et al. (1992) rated half as fair and poor. On the other hand, the DCS utilizes a cannulated reamer over a guide-pin for the screw portal, and sagittal malalignment (apex anterior and apex posterior) can be easily corrected, even with the screw inserted. However, the DCS has also some disadvantages: a large bone volume in the intercondylar region is necessary for placement of the lag screw and irritation of the iliotibial band by the bulk of the side plate of the DCS (Sanders et al. 1989, Albert 1997).

Although the ideal stiffness fixation for improving union has not yet been found, several authors have noted that constructs lacking stiffness will lead to increased motion with activity that may lead to nonunion (Firoozbakhsh et al. 1995, Koval et al. 1996). In this model of synthetic bone held in place with internal fixation, the DCS had better mechanical properties as compared to the ABP in axial compression. In the other modes of compression and in torsion, we found no significant differences between the two in axial compression. We also tested the constructs for maximal load, and the DCS was found to be significantly stronger. We tested 4 femurs in fatigue, 2 in each group, up to 80,000 cycles without detecting loosening or permanent deformation of the construct. Koval et al. (1996) suggest that testing for 10,000–20,000 cycles simulates 2–6 months of in vivo cyclic loading of the femur.

We consider that this data should be correlated to fractures similar to the pattern tested in this study, i.e., metaphyseal complex extraarticular supracondylar femoral fracture (OTA Classification 33-A3). If a derotational screw cannot be placed in the distal fragment when using the DCS, then the construct would be much less stable in anterior and posterior compression because of rotation around the lag screw. With this type of fracture pattern, the ABP would be better, since it may give greater rotational stability. More studies should be done to determine which construct is optimal for particular types of fracture, including intraarticular supracondylar fractures.

This study showed that the 95° angle blade plate had no mechanical advantage over the 95° condylar side plate and screw when used to fix a comminuted extraarticular supracondylar femoral fracture in a synthetic bone model.

The authors have received no financial support or compensation. The devices used in this manuscript have been approved by the FDA. We thank Mr. Jim Pound and Synthes USA for providing the devices.

Albert M J. Supracondylar fractures of the femur. J Am Acad Orthop Surg 1997; 5: 163-71.

David S M, Harrow M E, Peindl R D, Frick S L, Kellam J F. Comparative biomechanical analysis of supracondylar femur fracture fixation: locked intramedullary nail versus 95-degree angled plate. J Orthop Trauma 1997; 11: 344-50.

Firoozbakhsh K, Behzadi K, DeCoster TA, Moneim MS, Naraghi FF. Mechanics of retrograde nail versus plate fixation for supracondylar femur fractures. J Orthop Trauma 1995;9:152-157

Ito K, Grass R, Zwipp H. Internal fixation of supracondylar femoral fractures: comparative biomechanical performance of the 95-degree blade plate and two retrograde nails. J Orthop Trauma 1998; 12: 259-66.

Koval K J, Kummer F J, Bharam S, Chen D, Hlader S. Distal femoral fixation: a laboratory comparison of the 95° plate, antegrade and retrograde inserted reamed intramedullary nails. J Orthop Trauma 1996; 10: 378-82.

Lueng K S, Shen W Y, So W S, Mui L T, Grosse A, Shatin NT . Interlocking intramedullary nailing for supracondylar and intercondylar fractures of the distal part of the femur. J Bone Joint Surg (Am) 1991; 73: 332-40.

Merchan E C R, Maestu P R, Blanco R P. Blade-plating of closed displaced supracondylar fractures of the distal femur with the AO system. J Trauma 1992; 32: 174-8.

Moehring H D. Flexible intramedullary fixation of femoral fractures. Clin Orthop 1988; 227: 190-200.

Müller M E, Allgöwer M, Schneider R, Willenegger H. Manual of internal fixation: techniques recommended by the AO-ASIF group. Springer-Verlag 1995.

Prichett J W. Supracondylar fractures of the femur. Clin Orthop 1982; 184: 173-7.

Sanders R, Regazzoni P, Ruedi T P. Treatment of supracondylar-intracondylar fractures of the femur using the dynamic condylar screw. J Orthop Trauma 1989; 3: 214-22.

Sanders R, Swiontkowski M, Rosen H, Helfet D. Double-plating of comminuted, unstable fractures of the distal part of the femur. J Bone Joint Surg (Am) 1991; 73: 341-6.

Schatzker J. Fractures of the distal femur revisited. Clin Orthop 1998; 347: 43-56.

Shelbourne K D, Brueckmann F R. Rush-pin fixation of supracondylar and intercondylar fractures of the femur. J Bone Joint Surg (Am) 1982; 64: 161-9.

Siliski J M, Mahring M, Hofer H P. Supracondylar-intercondylar fractures of the femur: treatment by internal fixation. J Bone Joint Surg (Am) 1989; 71: 95-104.