Coll. Antropol. **32** (2008) 4: 1129–1132
Original scientific paper

Transfixed Condylar Plate (TCP) Provides Better Biomechanical and Weight Bearing Possibilities for the Fixation of Trochanteric Fracture

Josip Turčić, Ivan Dobrić and Tonisav Antoljak

Department of Traumatology and Bone and Joint Surgery, Surgical Clinic, University Hospital Center »Zagreb«, Zagreb, Croatia

A B S T R A C T

The goal of this research was to find the implant which would provide a better possibility of the fractured osteoporotic bone weight bearing after trochanteric fracture fixation. The authors constructed a new implant based on the conventional condylar plate, as part of a stabile triangular system. Because of the special oblique form of the screw which absolutely stabilizes vertical and horizontal arm of the plate, this plate was named the transfixed condylar plate (TCP). Analysis showed 6 kN of tolerant loading elastic in TCP with a longer horizontal arm, while this value in the conventional condylar plate was 2.5 kN. Also, dynamic resistance was 2.4 times higher in TCP then in the control model. These improved biomechanical results of this plating fixation system are expected to be found in the clinical use of this plate. This would enhance an early rehabilitation and a better functional outcome.

***Key words**: trochanteric fracture, fracture fixation, implants, transfixed condylar plate*

Introduction

Proximal femur fracture is one of the most common fractures in the elderly. The expected rate of these fractures in the year 2050 is about 70%. The main reason for this is a tendence of a longer life-expectancy presented in the last few decades[1]. This definitely increases the number of older people in the society. Furthermore, this has lead to new challenges in traumatology, trying to find the optimal surgical solution in treating proximal femoral fractures, and even resolve the problems which were found impossible to resolve so far [2]. The main aim of any operative method used before was to verticalize the patient as soon as possible, with limited or full weight bearing. This finally reduces a huge number of complications, provides faster social reintegration, and also better life quality. Anyway, treating proximal femoral fractures does not always results in success, because elderly people are often not able to control weight bearing in the recovery period. This could lead to new fall with a possible injury of the operated hip[3]. Osteoporosis could also be the cause of implant dislocation[4–9].

So searching for the implant for fixing a proximal femoral fracture which could provide full weight bearing in early post operating period is steel needed.

Implants which could provide stabile fixation of proximal femoral fractures were developed when certain surgeons based their researches on removing unsatisfactory characteristics of the implants used so far. Biomechanical researches, as well as model researches, were the base for the further development and the construction of new implants. These experiments found out possibilities for the optimal positioning of the implant on osteoporotic bone, and provided earlier weight bearing, with a decreased risk of implant dislocation[3–6,9–13].

Unstable fractures of trochanteric region, from A2 and A3 group of AO classification, could be fixed by extramedullary or intramedullary fixation. Tumor prosthesis or external fixator could also be used, but only in special conditions. Angled plate 130°, condylar plate 95°, or dynamic hip screw (DHS) could be used for extramedullary fixation. The protrusion of these implants into acetabulum presents the main complication after the fixation and verticalisation of the patient with a reduced bone mass, despite the limited weight bearing. Intramedular implants like gamma nail or proximal femoral nail are not exposed to the forces which could deform or

Received for publication October 16, 2008

break extramedular implants because of the high force moment[3–9]. Due to their biomechanical charasteristics (shorter vertical part, increased resistans to the force), they provide an early full weight bearing. Rotational mistake could be prevented by using other bicortical screws or T double horizontal part[3]. Intramedular fixation could be performed using minimal invasive surgical technique. On the other hand, these implants are more expensive then extramedular. They also cause mutilation by the widening of the medullar canal which could be the cause of serious respiratory complications or implant fracture in case of an increased weight bearing.

The goal of this research is to construct a new extramedular device for a stabile proximal femur fixation which could provide higher strength, early full weight bearing and rotational stability.

The first extramedullary fixation of proximal femur fracture using modified angled plate with »buttressing stick« was reported by Weissman and Salama in 1969. This method was also modified a few times by the authors[11–13]. RAB plate was constructed following the same principles[6].

Materials and Methods

In order to achieve better resistance to tensioning and torsioning forces, we constructed the new transfixed condylar plate (TCP) (Figure 1). The construction was performed at the Department for development of Instrumentaria Co. The instruments for the implantation were also constructed and manufactured. As the base for the construction of the new plate we used condylar plate 95 degrees with seven screw wholes. An additional oblique whole was done for the placing of the transfixational screw. The idea was the fixation of the horizontal part of the plate through a tapped hole on both the vertical and horizontal part. Because of that, the horizontal part is 2 mm wider than the standard. Technical engineers solved the mechanical problem of tapping the vertical and horizontal hole in 90 mm distance in the same coiling line.

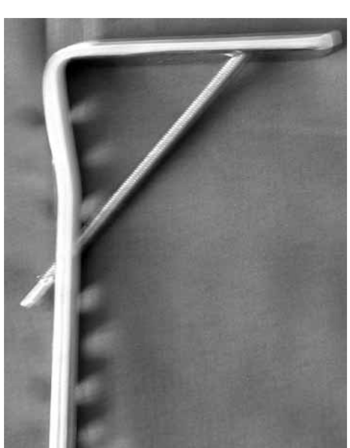

Fig. 1. Transfixed condylar plate (TCP).

The distance between entry and exit hole and the top of the angle were ordered following the reports of Weisman and Salama[11].

The aim of the transfixational screw M6 with a sharp top and four borders is to fixate the vertical and horizontal part of the plate forming a stable block. In clinical use this should increase the level of weight bearing, reduction of torsional moments, prevention of cranial and lateral movements of greater trochanter, and medial movements of proximal part of femoral shaft. The transfixational screw is placed after the bone drilling using a 4 mm drill. The transfixational screw body diameter is also 4 mm. As mentioned before, leading and soft tissue protecting devices were also constructed.

In this research we used the plate models with a longer and a shorter horizontal part. They both had a horizontal part 2 mm wider then the conventional condylar plate. Both models were analyzed using a hydraulical stress machine at the Laboratory for mechanical engineering of the Faculty of mechanical engineering of Zagreb University. The conventional condylar plate, with a shorter and a longer horizontal part and of standard width, was used as control. The number of taps was the same for all plates.

Results

During the initial deformation analysis after vertical bearing we registered irregular values in the plastic deformation segment, because of the deformation of the coil in the horizontal part of the plate. After some technical improvement of the joint complex between transfixational screw and horizontal part of the plate, the measured values became regular.

After a repeated analysis we got the results presented like elasticity modulus shown in figure 2. From these results it is obvious that after the vertical loading of the plate with the long horizontal part, the loading diagram line separates from Hook's line after applying a 6 kN pressure, which presents an optimum 5 mm elastic deformation. After the vertical loading of the transfixational plate with the short horizontal part, the optimum elastic deformation of 4.7 mm was measured with loading force of 3 kN. In comparison to these results, we measured the highest vertical loading values of the conventional condylar plates with a long and short horizontal part. The deformation of 3.8 mm appeared after loading 2.5 kN on the plate with the long horizontal part, and 3.8 kN on the plate with the short horizontal part.

Discussion

Loading forces to the trochanteric region of the femur vary during different activities. While standing, this region is loaded up to 60% of the body weight. Standing on one leg increases the loading up to 4–7 times of the body weight, while when walking this load is increased up to 3 times of the body weight. The loading force while getting on and out of the bed is equal to four times of the body weight. This loading alterations lead to trochanteric fractures, mostly in elderly people due to the bone mass loss caused by osteoporosis, but also in younger people because of the high energy transmission.

Intertrochanteric fractures are characterized by anatomic patterns that vary in their degree of stability following their fixation and almost always should be treated operatively. We have already mentioned some reasons for many implants used in operative treatment of trochanteric femur fractures so far. Clinical trials of different implants for fixations of A2 and A3 fractures reported more or less plenty of technical failures which do not allow an adequate weight bearing and recovery of the patient.

Trochanteric fractures are usually treated by internal fixation, using devices such as the compression hip-screw and the angled blade plate. Compression hip-screws with a plate have gained increased popularity in the treatment of intertrochanteric fractures. These implants provide secure fixation and controlled impaction of the fracture. The rate of complications is relatively low with most frequent mode of failure being cut out of the screw from the femoral head[14–16]. Although these methods are used worldwide in operative treatment of trochanteric fractures, overall failure rates by different authors reported up to 12% device penetration., 5% non-union., and 11% malunion causing various deformity. Failed treatment of trochanteric fractures, using different internal fixation modalities, as previously described, results in increased functional disability and pain[17–19].

The first generation of intramedullary nails was developed to prevent these drawbacks, by combining the advantages of intramedullary fixation with those of a sliding screw. Mechanically, the shorter lever arm of the intramedullary nail decreases the tensile strain on the implant and thus reduces the risk of failure of the implant[14]. Nowadays, the rate of clinical failures of intramedullary devices has decreased to a range of 0% to 4.5% with the use of second-generation nails[15]. Hardy et al. also reported that patients treated with an intramedullary nail had a better mean mobility score in one year than those treated with a sliding hip-screw[16].

But still, many surgeons are not familiar with the intramedullary treatment of trochanteric fractures. These devices are also more expensive, and there are no clinical evidences which would confirm their superiority in efficiency or less side effects. A significantly higher radiation exposure during nailing of proximal femur also presents a negative side of this method[20].

Because of that we have constructed the new stabile extramedular triangle plating system, with an important role of the transfixating screw. This plating system looks like a building construction which transfers pressure from the roof to the walls of the object. The pioneers of this idea were Weismann and Salama[11], who constructed and then used angled, and thenafter condylar plate with an oblique screw from the vertical to horizontal arm of the plate. The main difference between their plate and our new plate was the tapped vertical, but not the horizontal part of the plate. So, the oblique screw in their plating method had only a »butressing« function, without stable joint complex between the vertical arm, the oblique transfixational screw and the horizontal arm of the plate. As a consequence, the vertical, lateral and rotational instability of the fixed fracture appeared. By tapping both the vertical and horizontal part of the plate, we constructed a stable triangle complex, and significantly reduced the above mentioned instabilities.

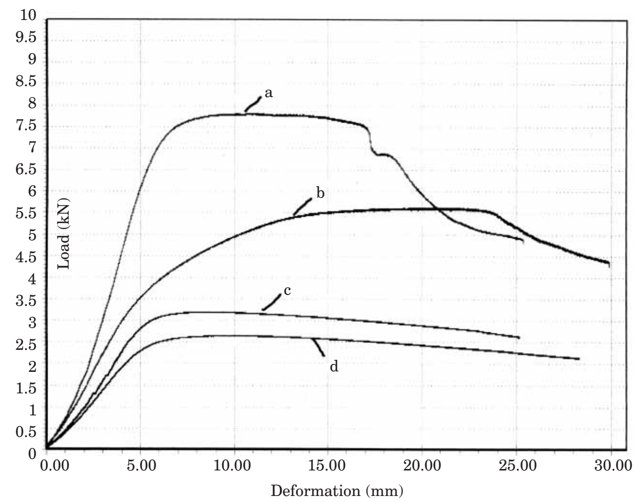

Fig. 2. Elasticity modulus comparison of TCP and conventional condylar plate: Line a – deformation of transfixed condylar plate with long horizontal arm, line b – deformation of transfixed condylar plate with short horizontal arm, line c – deformation of conventional condylar plate with long horizontal arm, line d – deformation of conventional condylar plate with short horizontal arm.

After the pilot analysis using hydraulic stress machine we registered the failure on horizontal joint complex, which is visible in the diagram line of the plastic deformation segment (Figure 2). We explained that failure as an impossibility of an ideal oblique coil. After the technical improvement of the plate, we did not register that form of the diagram line. In this research we did not directly measure the dynamic resistance of the model. It depends on many factors, like the total force of loading, type of the loading, total number of loadings etc. Its value is about 3/5 (60%) of static resistance. The quantification of all these factors would take a long time and various devices, so we used an indirect way to measure the dynamic resistance of all analyzed models, by decreasing the values to 60% of static resistance. Finally, we took 3/5 of 6 kN (3.6 kN) force for the transfixed condylar plate with the long horizontal part, and 2.5 kN (1.5 kN) force for the conventional condylar plate with the long horizontal part as the values of the dynamic resistance. The results showed that elastic deformation, but also the dynamic resistance, was 2.4 times higher in the transfixed condylar plate than in the control model. Similar values were measured in the analysis of the dynamic resistance of both transfixed and conventional condylar plates with the short horizontal part.

Conclusion

According to the results of this study, the authors find that TCP provides a good biomechanical condition for the fixation of trochanteric femoral fractures if it is performed by plating. This stable triangular system has shown better dynamic resistance in laboratory research than the conventional condylar plate. That gives us motivation to ask the permission from the Ethics Committee, but also the patients to start a controlled clinical trial.

REFERENCES

1. SMRKOLJ V, KOMADINA R, Gerontološka travmatologija (Grafika Gracer, Celje 2004). — 2. Posinković B, Prijelom vrata bedrene kosti (Školska knjiga, Zagreb 1985). — 3. FRIEDL W, CLAUSEN J, Chirurg, 72 (2001) 1344. — 4. MEDOFF RJ, MAES K, J Bone Joint Surg Am, 73 (8) (1991) 1192. — 5. BONG MR, PATEL V, IESAKA K, EGOL KA, KUMMER FJ, KOVAL KJ, J Trauma, 56 (2004) 791. — 6. BUCIUTO RH, J Trauma, 50 (2001) 545–50. — 7. LUNSJÕ K, CEDER L, THORNGREN KG, SKYTTING B, TIDERMARK J, BERNSTON PO, ALLVIN I, NORBERG S, HJALMARS K, LARSON S, KNEBEL R, HAUGGARD A, STIGSSON L, Acta Orthop Scand, 72 (2) (2001) 133. — 8. IM GI, SHIN YW, SONG YJ, J Orthop Trauma, 19 (2005) 5. — 9. JENSEN JS, TONDEVOLD E, MOSSING N, 49 (1978) 392. — 10. WEISE K, SCHWAB E, Chirurg, 72 (2001) 1277–82. — 11. WEISSMAN SL, SALAMA R, Clin Orthop, 67 (1969) 143. — 12. SALAMA R, WEISSMAN SL, Revue Chirurg Orhop, 59 (1973) 247. — 13. BRUNNER CF, WEBER BG, Besondere Osteotsynthesetechniken (Springer-Verlag Berlin Heidelberg New York 1981). — 14. DAVIS TRC, SHER JL, HORSMAN A, SIMPSON M, PORTER BB, CHECKETTS RG, J Bone and Joint Surg, 72-B (1) (1990) 26. — 15. LORICH DG, GELLER DS, NIELSON JH, Instr Course Lect, 53 (2004) 441. — 16. HARDY DC, DESCAMPS PY, KRALLIS P, FABECK L, SMETS P, BERTENS CL, J Bone Joint Surg Am, 80 (1998) 618. — 17. HAENTJENS P, CASTELEYN PP, OPDECAM P, Arch Orthop Trauma Surg, 113 (4) (1994) 222. — 18. KYLE RF, CABANELA ME, RUSSELL TA, Instr Course Lect, 44 (1995) 227. — 19. MARIANI EM, RAND JA, Clin Orthop, 218 (1987) 81–9. — 20. SHAH NH, WALTON NP, SUDHAHAR TA, DONELL ST, Injury, 35 (10) (October 2004) 1010.

I. Dobrić

Department of Traumatology and Bone and Joint Surgery, Surgical Clinic, University Hospital Center »Zagreb«, Kišpatićeva 12, 10000 Zagreb, Croatia
e-mail : i_dobric@yahoo.com

TRANSFIKSIRANA KONDILARNA PLOČA (TCP) POKAZUJE BOLJE BIOMEHANIČKE REZULTATE I MOGUĆNOSTI OPTEREĆENJA NAKON OSTEOSINTEZE TROHANTERNOG PRIJELOMA BEDRENE KOSTI

SAŽETAK

Cilj ovog istraživanja je konstrukcija implantata koji bi omoućio bolje mogućnosti opterećenja osteoporotične kosti nakon osteosinteze trohanternog prijeloma bedrene kosti. Autori su konstruirali novi implantat koji se bazira na konvencionalnoj kondilarnoj ploči, kao dijelu stabilnog trokutastog sustava. Zbog specifičnog kosog oblika vijka koji rigidno stabilizira vertikalni i horizontalni krak ploče, ovaj implantat nazvan je transfiksirana kondilarna ploča. Rezultati pokazuju tolerantno opterećenje do pojave elastične deformacije od 6 kN kod transfiksacijske kondilarne pločice s dužim krakom dok kod konvencionalne kondilarne pločice opterećene u istim uvjetima ono iznosi 2,5 kN. Dinamička rezistencija kod TCP pokazala je 2,4 puta više vrijednosti od konvencionalne kondilarne ploče. Autori očekuju potvrdu ovih eksperimentalnih rezultata i u kliničkoj primjeni, što bi omogućilo raniju rehabilitaciju i bolje funkcionalne rezultate.