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Transarticular Approach and Retrograde Plate Osteosynthesis (TARPO) Using Implants with Angular Stability – A Series of 17 Cases of Complex Distal Femoral Fractures Type C3/AO

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Rezumat

Abordul transarticular și osteosinteza retrogradă cu plăci (TARPO) utilizând implante cu stabilitate angulară - o serie de 17 cazuri de fracturi complexe ale femurului distal tip C3/AO

Obiective: Obiectivul acestui studiu retrospectiv este reprezentat de evaluarea rezultatelor fracturilor femurului distal tip C3/AO utilizând abordul transarticular și osteosinteza retrogradă (TARPO) cu plăci cu stabilitate angulară.
Material și metode: Studiul include 17 fracturi tip C3/AO cu 4 fracturi deschise: 1 tip I, 1 tip II și 2 tip IIIA cu pierdere osoasă/Gustilo. Pacienții au fost operați prin tehnica TARPO, folosind Less Invasive Stabilization System - LISS (4 cazuri), Locked Compression Plates - LCP (8 cazuri) și plăci cu stabilitate angulară poliaxială (5 cazuri). Stabilitatea excelentă a montajului a permis recuperarea imediată. Pacienții au fost urmăriți timp de minimum 12 luni.
Rezultate: 15 fracturi au consolidat într-un interval mediu de 12,6 săptămâni, în timp ce 2 pacienți cu fracturi deschise și defecte osoase au necesitat grefare osoasă secundară. Nu s-au înregistrat infecții sau deteriorări ale montajului. Rezultatele conform scorului Neer au fost excelente în 9 cazuri și satisfăcătoare în 7 cazuri (o urmărire incompletă).
Concluzii: Această tehnică pretențioasă are avantajul unei consolidări rapide, cu îmbunătățirea vizualizării articulare. Plăcile blocate reprezintă o alternativă unică în fracturile femurului distal tip C3/AO, în fracturile pe osteoporoză și cele deschise.

Cuvinte cheie: TARPO, fracturile femurului distal, LISS, LCP, stabilitate angulară poliaxială

Abstract
Aim: The aim of this retrospective study was to evaluate the outcome of distal femoral fractures type C3/AO, using TARPO technique and plates with angular stability
Material and Methods: The study included 17 fractures type C3/AO, with 4 open fractures: 1 type I, 1 type II, and 2 type IIIA with bone loss/Gustilo. All patients were operated by TARPO technique using Less Invasive Stabilization System-LISS (4 cases), Locked Compression Plates-LCP (8 cases) and plates with polyaxial stability (5 cases). The excellent stability of the construct allowed fast knee rehabilitation. The follow-up period included at least 12 months.
Results: 15 fractures healed within a mean time of 12.6 weeks, while 2 cases with open fractures and bone loss required secondary bone grafting. We recorded no infection or implant failures. The outcome using Neer scale was excellent in 9 cases and satisfactory in 7 cases (1 patient with discontinued follow-up).

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Conclusions: This demanding TARPO technique has the advantage of a faster rate of union and improved exposure of the knee joint. The locked plates provide a unique alternative in distal femoral fractures type C3/AO, as well as in osteoporotic and open fractures.

Key words: TARPO, distal femoral fractures, LISS, LCP, polyaxial stability

Introduction

Few trauma show more therapeutic issues than fractures of the distal femur. Classic open reduction and internal fixation (ORIF) using condylar blade plate (CBP) or Dynamic Condylar Screw (DCS) requires large incisions, perforating arteries ligature and fragment deperiostation that led to an increased complication rate: infections, union delays, non-unions, iterative fractures and an increased need for primary or secondary bone grafting (1,2). All these disadvantages determined the development of the biological osteosynthesis concept, based on the preservation of the soft tissues that led to a faster rate of union with few complications (3).

While minimally invasive plate osteosynthesis (MIPO) techniques were successfully applied in complex extraarticular fractures of the proximal and distal femur (4) the technique entitled Transarticular Approach and Retrograde Plate Osteosynthesis – TARPO was developed for complex supra- and intercondylar femoral fractures (5) (*Fig. 1*).

Unfortunately, classic plates are not conceived for MIPO or TARPO and their usage may lead to important complications: primary or secondary fragment displacement due to construct failure (mainly in fractures on osteoporotic bones or in comminuted periartricular fractures) as well as periosteal compression that determines the blood flow reduction (6,7). The requirements for the biological osteosynthesis led to the development of a new generation of plates with angular stability (internal fixators), called Less Invasive Stabilization System (LISS) (7). The next acquisition was the locked compression plate (LCP) with combi-holes (6,8) and the newest plates with polyaxial stability (9). Early reports with biological plating with internal fixators have shown promising results regarding union rates, alignment and construct stability, fast rehabilitation and infrequent complications (10,11).

Aim

The aim of this retrospective study was to evaluate the outcome of the complex distal femoral fractures type C3/AO, treated with TARPO technique using plates with angular stability. At the same time, there are emphasized the steps, difficulties and some tips and tricks regarding this innovative technique, implants and instruments.

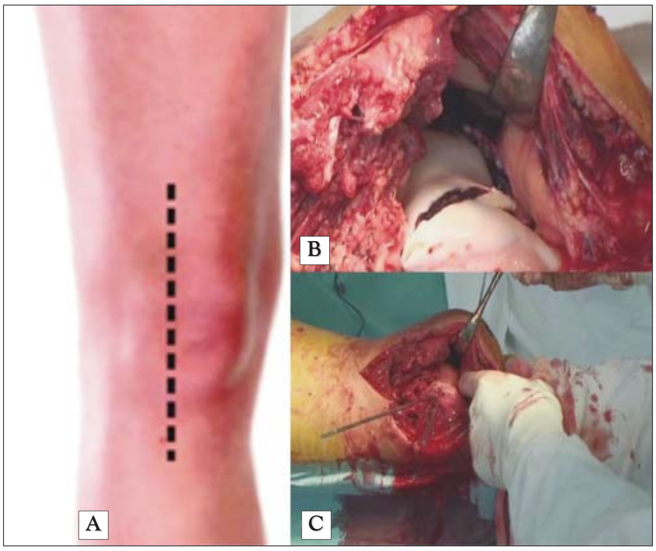

Figure 1. *TARPO technique. **(A)** incision line with lateral parapatellar arthrotomy; **(B)** medially retraction of patella and exposure of femoral condyles; **(C)** articular reconstruction and temporary fixation with Kirschner wires*

Material and Methods

Between October 2006 and October 2011, 17 patients (10 males and 7 females) with complex fractures of the distal femur type C3/AO were admitted and operated on. The mean age was 43.8 years (range 22-79 years). All injuries were produced by high energy trauma (14 road traffic accidents, and 3 work related incidents), 11 patients being polytraumatized. The study group included 4 open fractures: one type I, one type II and two type IIIA with bone loss/Gustilo. All patients were operated using TARPO technique and plates with angular stability (LISS plates in 4 cases, LCP plates in 8 cases and plates with polyaxial stability type NUMELOCK in 5 cases) (*Fig. 2*).

Surgical technique

Preoperative planning included high quality radiographies of the injured and contralateral femurs and careful measurement of the contralateral femoral length. The operative moment was dictated by patient stability, within a mean time of 4.1 days from injury (range 1-12 days). The open fractures were operated in the first hours after admission. Fractures type II and IIIA/Gustilo were initially immobilized with a bridge external fixator with 2 femoral and 2 tibial pins. The surgery was performed under spinal or general anesthesia, on a traction table, using a C-arm image amplifier; all patients were placed in dorsal decubitus.

The first step to solve supra- and intercondylar femoral fracture was the joint reconstruction, according to the technique developed by Krettek (4,5). Following an antero-lateral skin incision of 15-20 cm, a laterally parapatellar arthrotomy was performed and was continued proximally (among the fibres of the rectus femoris and vastus lateralis) and distally up to the

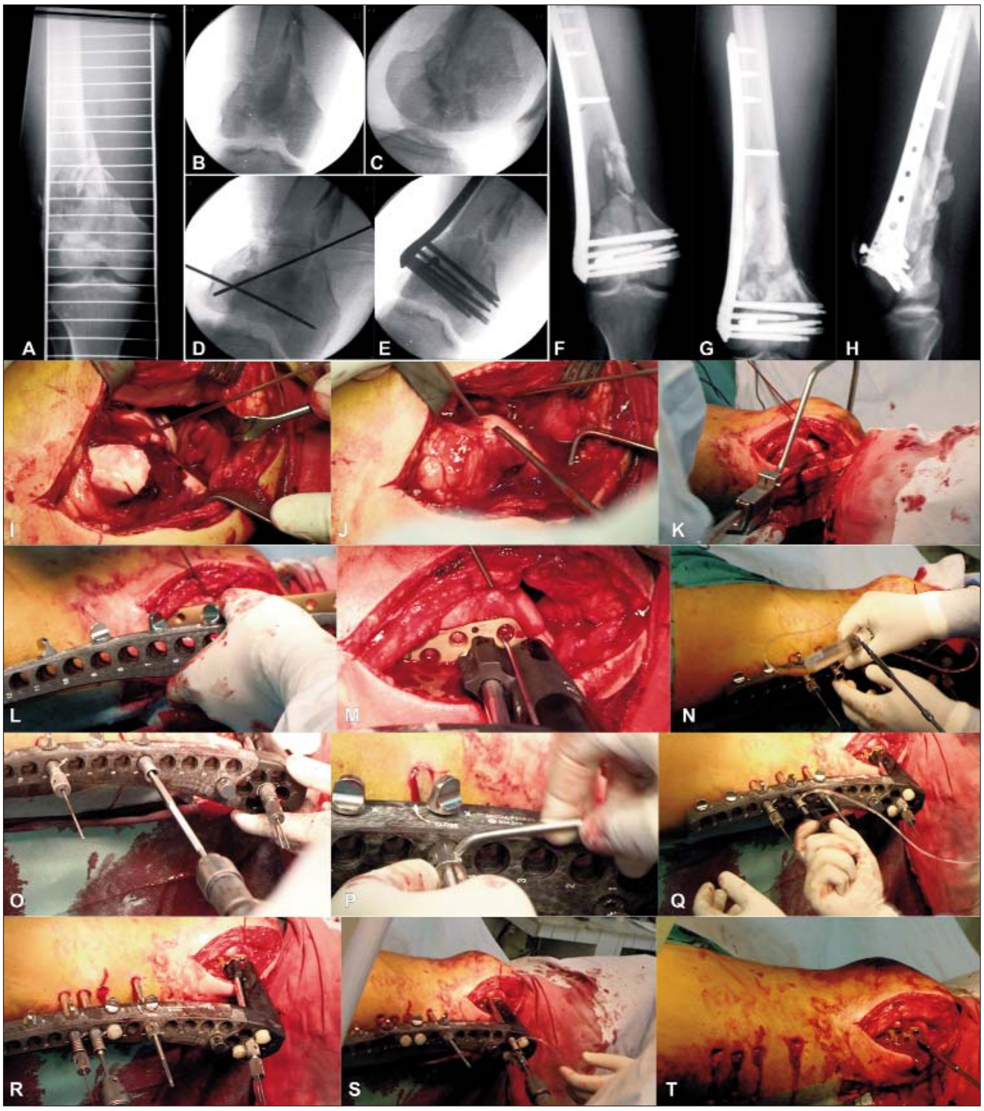

Figure 2. *TARPO technique with LISS in a distal femoral fracture type C3/AO. **(A)** preoperative aspect; **(B,C)** fluoroscopic control prior to surgery; **(D,E)** articular reconstruction and fixation with LISS plate; **(F)** postoperative X-ray showing excellent axis reestablishment; **(G,H)** fracture healing at 5 months postoperatively; **(I,J)** intraarticular comminution with anatomical reduction with Kirschner wires and special clamps; **(K)** intercondylar reduction using collinear reduction clamp; **(L)** LISS insertion with aiming device; **(M)** distal LISS fixation with Kirschner wire; **(N)** cooling system setup to prevent thermal necrosis; **(O,P)** usage of whirly-bird system to bring the bone to the plate; **(Q)** complete locking by torque-limiting screwdriver; **(R)** percutaneous proximal screw insertion; **(S)** distal screw insertion; **(T)** insertion of the last distal screw after aiming device removal*

tibial tuberosity. By this procedure, the patella was medially retracted, allowing perfect visualization for femoral condyles. Following direct reduction of the articular surface (using Schantz pins as joysticks, Weber clamps or a collinear reduction clamp) and its stabilization by provisional Kirschner wires (*Fig. 2 I-K*), fixation was performed by 1-2 classic or cannulated cancellous screws.

Following articular surface reconstruction and indirect reduction of the metadiaphyseal region, LISS and LCP plates were inserted beneath the vastus lateralis using a special radiolucent aiming device (*Fig. 2 L*). The alignment and position of the plate on the diaphysis was checked by fluoroscopic control and the plates were provisionally fixed by proximal and distal Kirschner wires (*Fig. 2 M*). A special cooling system was used to prevent thermal necrosis during insertion of the self-drilling and self-taping screws (*Fig. 2 N*). The only problem with the plates with angular stability is that it requires an accurate close reduction prior to screw insertion. The locked screws are striving to push the diaphysis instead bringing it to the plate (as in classic implants). In these cases, the alignment of the metadiaphyseal component was performed by a special device type “whirly-bird” which maintained the diaphysis onto the plate during screw insertion (*Fig. 2 O-P*). The screws inserted through special holes of the

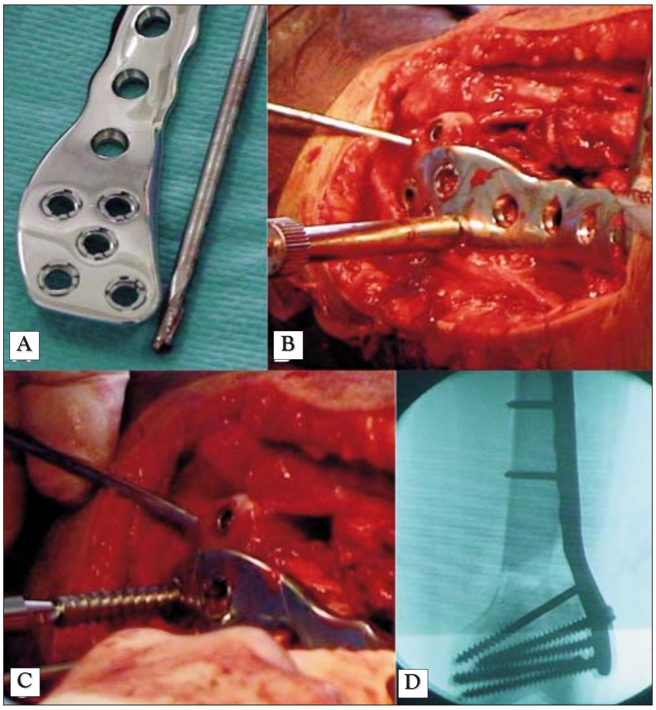

Figure 3. *TARPO technique with plate with polyaxial stability (PAS) in distal femoral fractures type C3/AO, open type IIIA Gustilo with bone loss.* ***(A)*** *PAS plate type Numelock;* ***(B)*** *plate fixation on the condyle;* ***(C)*** *insertion of the distal locked screw;* ***(D)*** *intraoperative fluoroscopic control of excellent reduction (with residual bone defect) and PAS plate fixation*

aiming device were locked completely using a torque-limiting screwdriver (*Fig. 2 R*). At least 4-5 screws were subsequently placed both proximally and distally (*Fig. 2 R-S*). During procedure development, the axis and rotation reestablishment was checked. Following aiming device removal, a distal locked screw was inserted in the remaining hole (*Fig. 2 T*). In 3 cases, additional proximal incisions were used, corresponding to the last holes in the plate (for long plates with 11-13 holes) in order to visualize the perfect plate placement onto the diaphysis and to reduce X-ray exposure. For plates with polyaxial stability that are not endowed with an aiming device, a retrograde insertion beneath the vastus lateralis was used, together with a proximal fixation with at least 4 cortical screws through an additional 4-5 cm proximal incision (*Fig. 3*).

Postoperative care and follow-up

Postoperatively, all patients started functional rehabilitation type "continuous passive motion" on a „KINETEC" system and were mobilized by axillary crutches without weight bearing on the operated limb. Partial weight-bearing was allowed on radiological callus appearance and continued progressively up to the total weight bearing together with significant radiologic favorable evolution toward union in the metadiaphyseal area. All patients were followed clinically and radiologically for a minimal period of 12 months (mean 16.5 months, range 12-36 months); in the first 6 months, controls were performed at 4-6 weeks and then at 3-6 months. The operating time, the x-ray exposure, postoperative radiographic aspects and complications, time to fracture union and the functional results according to Neer score were recorded (5).

Results

The mean operating time was 88.3 minutes (range 65-230 minutes). The usage of image intensifier was recorded by the number of radiation exposure (mean 28, range 19-65).

15 fractures healed within a mean time of 12.6 weeks (range 8-20 weeks) without primary or secondary bone grafting. In 1 case of open type IIIA fracture and bone loss we performed a secondary bone graft combined with osteoconductive bone substitute (with excellent healing at 2 months). The other case with open fracture type IIIA and bone loss was operated with polyaxial Numelock plate (with persistence of a residual bone defect) (*Fig. 3*); this polytrauma case developed postoperative abdominal complications and renal failure. Following recovery, the patient was operated in another medical unit (bone grafting) but the follow-up was discontinued. At the most recent follow-up, the radiographic assessment regarding varus/valgus alignment showed excellent axis reestablishment, except a deviation of 5-10 degrees in valgus in 2 cases. In the sagittal plane we recorded 1 case with a deviation of 5-10 degrees in recurvatum. Differences in limb length were around 0.6 cm (range between 0-1.5 cm) with one shortening and one lengthening over 1 cm.

We recorded no infection, implant failures or refractures. In the study group, the average knee flexion was 108 degrees (range 85-145 degrees) and the average knee extension was 5 degrees (range 0-10 degrees). From the group of 16 patients with complete follow-up, 9 had excellent results while the other 7 showed satisfactory results according to Neer score (5).

Discussions

While MIPO techniques improved healing rates in complex periarticular fractures (4), the plates with angular stability increased the construct stability and preserved the vascularity by percutaneous insertion of plate and screws as well as no need for bone-plate contact (8). The LISS system for distal femur (LISS-DF) consists of a titanium anatomically countered "buttress" plate with round threaded holes in which the self-drilling and self-taping screws locks; the LISS acts mechanically as an internal fixator and avoids the problems related to the bone-plate interface (7). The next step in improvement of plates with monoaxial stability was the LCP with combi-holes that allows the usage either of standard screws (for bringing the bone to the plate and for the meta-diaphyseal compression) or locked screws which maintain the reduction (6,8). The preformed angles of the holes create difficulties in complex articular fractures and for this special situation the plates with polyaxial stability (PAS) were developed; after changing the trajectory of the screws by 15 degrees in any direction according to the fracture patterns, the screws are locked into the plate. The difference in rigidity between PAS plates and plates with monoaxial stability is still "unclear" (9). The key for excellent rates of healing for TARPO is preservation of blood supply in metadiaphyseal region (5) as well as the elasticity of the construct (7,8). However, TARPO is demanding and axis and rotation reestablishment is crucial; for the frontal plane we have used the "cable technique", while for rotational alignment we have used the "lesser trochanter shape sign" (5).

Regarding a long experience with MIPO techniques and PAS plates, we can emphasize some keys to success, as well as some tips and tricks: excellent articular fracture reconstruction, the usage of longer plates with few spaced screws, an accurate metadiaphyseal fracture reduction before plate insertion and screw drilling, bicortical screws in osteoporotic fractures, avoidance of the eccentric plate placement, full weight bearing allowed when callus is seen in serial postoperative radiographs.

Even if the present study included only 17 patients with no control group, we consider that the fractures type C3/AO selected for TARPO technique were extremely difficult and our results are consistent with the literature data (10-12). Except 2 cases with severe open fractures and massive bone loss that required secondary bone grafting, the other 15 cases healed uneventfully within a mean time of 12.6 weeks. By careful plate insertions (beneath the vastus lateralis, following tunneling tools usage) no vascular lesions were recorded.

Conclusions

This demanding TARPO technique has the advantage of a faster rate of union, no need for bone grafting and improved exposure of the knee joint. Care should be taken to ensure adequate axial and rotational alignment. The plates with angular stability provides an unique alternative in multiplane complex fractures type C3/AO with short distal fragment; at the same time osteoporosis and open fractures which complicate this difficult lesion could be managed only by this innovative plates.

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