The treatment of transtrochanteric fractures of the femur with a minimally invasive technique using an extramedullary implant MINUS System

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Abstract We report here the results of a retrospective study on 120 patients treated for transtrochanteric fractures of the femur using a minimally invasive technique with an extramedullary sliding pin as implant – which we denoted the MINUS System. The evaluation was carried out in the postoperative period, and the levels of haemoglobin (Hb) and haematocrit (Ht), surgical time, radiological screening time and pain levels were recorded. Prior to the operation, mean Hb and Ht were 11.69 g/dl and 35.72%, respectively; in the immediate postoperative period, they were 10.35 g/dl and 32.4%, respectively. Mean operating time was 39.35 min. Average postoperative pain was assessed at 4.44 (on a scale of 1 to 10). The average time for screening was 1.07 min. Based on these criteria, we conclude that the minimally invasive technique of the MINUS System allows for a shorter operating time and a minimal blood loss in the treatment of transtrochanteric fractures of the femur.

Résumé 120 patients ont été opérés d'une fracture transtrochantérienne du fémur par technique mini invasive en

utilisant une ostéosynthèse par une vis plaque (MINUS Système). Ces patients ont été analysés de façon rétrospective. L'évaluation a été analysée en post opératoire en prenant en considération le taux d'hémoglobine et l'hématocrite, le temps opératoire, le temps de scopie et la douleur. En préopératoire, le taux moyen d'hémoglobine et d'hématocrite sont respectivement de 11,69 g avec un hématocrite à 35,72%, en post opératoire le taux d'hémoglobine était à 10,35 g et l'hématocrite à 32,4%. Le temps moyen de l'intervention a été de 39,35 minutes. La douleur moyenne en post opératoire a été cotée à 4,44. Le temps moyen d'exposition aux rayons par scopie a été de 1,07 minutes. En conclusion, la technique d'ostéosynthèse par voie mini invasive utilisant le système MINUS permet de raccourcir le temps opératoire et d'économiser les pertes sanguines dans le traitement des fractures transtrochantériennes du fémur.

Introduction

Transtrochanteric fractures of the femur account for nearly 50% of all hip fractures [11] and are very common among the elderly population. Statistics in the USA predict that, with the steadily increasing number of elderly Americans, the figure of 250,000 hip fractures reported in 1990 may double by the year 2040; this increase represents a annual cost of 16 billion dollars [6]. Despite the socio-economic importance of providing reliable treatment, approximately 50–60% of all transtrochanteric fractures are classified as unstable [20]. This represents a great challenge to the operating surgeon, as the rate of failure for these kinds of fractures vary from 8 to 25% [14].

The aim of treating transtrochanteric fractures is to enable the patient to return to his/her preinjury activity level

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in order to avoid complications associated with long periods of immobilisation [17].

At present, the implants of choice are the sliding pin plate and intramedullary nails [5, 7, 8, 18, 19]. The history of the long use of the Dynamic Hip Screw (DHS), its known learning curve and its significantly good standing among surgeons just adds to its fame of a gold standard to which other implants are compared. However, the need for a relatively large incision with the DHS and given that blood loss proportional to the incision size, emphasises the need to explore less invasive techniques for the treatment of these fractures.

Taking these factors into consideration, we report on a new implant and an accompanying technique that reduces the size of the incision for its insertion from 10 cm to approximately 3 cm. This combination implant-technique transforms the sliding pin plate to a minimally invasive technique. We have denoted this new implant as the MINUS System.

Materials and methods

This study consists of a retrospective analysis of 142 patients with transtrochanteric fractures of the femur who were treated at the Hospital Panamericano in São Paulo from September 2002 to September 2004. Inclusion criteria included a radiographic diagnosis of transtrochanteric fracture classified according to the criteria of Tronzo I–IV, preoperative laboratory/clinical analyses, including haemoglobin (Hb), haematocrit (Ht), sodium, potassium, urea, creatine, fasting plasma glucose test, electrocardiogram and chest X-ray, postoperative results of these same analyses, all prescriptions since the patient's first day in hospital up to his/her discharge, pre-operative and postoperative radiographs, pre-operative clinical evaluation and a declaration of never having had a blood transfusion.

Fig. 1 General view of the material

With respect to these criteria, 120 patients who were treated by the same physician signed a term of uncoerced consent in order to participate in this study. Tronzo V transtrochanteric fractures and other pathological fractures were excluded from the study. Patients were treated by anatomical reduction and to the sliding pin plate method of fixation that works for the MINUS System through a minimally invasive technique.

Materials

The MINUS System comprises an extramedullary sliding pin plate with three holes and the instruments for its insertion. Figure 1 provides a general outline of the instruments, while detailed descriptions are as follows. The instruments comprise:

- 01 depth probe for the sliding pin – aluminium B221M;
- 01 plate guide – aluminium B221M;
- 02 drill Ø 3.2×250 mm – stainless steel AISI 420;
- 01 external sleeve – stainless steel AISI 420;
- 01 internal sleeve – stainless steel AISI 420;
- 01 guide screw for the plate M6×1 – stainless Steel AISI 420;
- 01 guard for the drill – stainless Steel AISI 420;
- 01 135° guide – stainless steel AISI 420;
- 01 T-Handle – stainless steel AISI 420;
- 01 rotational tweezers – stainless steel AISI 420;
- 01 rotational wrench – stainless steel AISI 420;
- 01 tap Ø 13 mm – stainless steel AISI 420;
- 01 depth probe for the screw – stainless steel AISI 420;
- 01 Impactor – stainless steel AISI 420;
- 01 external spanner for the sliding pin – stainless steel AISI 420;
- 01 internal spanner for the sliding pin – stainless steel AISI 420;
- 01 spanner for cortical screw – stainless steel AISI 420;
- 04 calibrated guide wire Ø 2.5×230 mm – stainless steel ASTM F138;
- 04 calibrated guide wire Ø 2.5×300 mm – stainless steel ASTM F138.

All instruments are machined, with the exception of the tweezers and rotational wrench, which are forged.

The implants consist of:

- 03 cortical screws Ø 4.5 mm of self-tapping thread (range: 28–54 mm in length variances of 2 mm) – stainless steel ASTM F138 or titanium alloy ASTM F136;
- 01 hexagonal sliding pin (range: 60–120 mm in length variances of 5 mm) – stainless steel ASTM F 138 or titanium ASTM F136;

Fig. 2 Patient positioning on the radiotransparent table

- 02 MINUS plates – forged titanium ASTM F136/ASTM F620; thickness of the plate: 6.5 mm; number of plate holes for screw placement: 3.

All implants are machined, with the exception of the plate, which is forged.

Operative technique

The patient lies in supine position on a radiolucent table, and a 5-cm pillow is often placed under the patient's buttocks at the site of the fracture to shorten the anteversion effect of the femoral neck and to facilitate the access to the proximal diaphysis of the femur. This positioning is particularly important if the patient is obese (Fig. 2).

The quality of the reduction is assessed through the image intensifier; this is the first surgical procedure. Both stable and unstable fractures, must have anatomical reduction. Following reduction, the fracture is fixed temporarily with two Kirschner wires (diameter: 2 mm) across the greater trochanter going over the superior part of the femoral neck to the femoral head (Fig. 3).

In general, the incision is made 2 cm under the base of the lesser trochanter at the point of intersection with the diaphysis of the femur, when this is comminuted or avulsed

(Fig. 4). The incision starts 2 cm distal to the end of the calcar; through this point, a 3-cm incision is made through the skin, subcutaneous cellular tissue and fascia lata. The vastus lateralis is separated in the line of its fibres to the bone using a Kelly tweezers. The guide wire is positioned at the centre of the neck and head of the femur in the anteroposterior and lateral views using a 135° guide, avoiding the interposition of part of the vastus lateralis between the guide and the diaphysis of the femur to prevent any possible error in its placement (Fig. 5). An image intensifier is used. A depth probe is used to determine the pin's size. The drill-hole and reaming of the femoral neck is carried out using the reamer for three different levels; the size has been previously determined by the guide wire. A retractor is used to protect the soft tissues from laceration. This is followed by the tapping of the canal using a 13.0-mm tap. The sliding pin must be 5.0 mm longer than canal in order to be visible in the lateral side of the femoral cortex so as to facilitate the attachment of the tube with the plate. The plate must be inserted with its tube facing the surgeon, using tweezers for handling the plate. The surgeon slides the plate over the vastus lateralis, making a 180° turn in its axis to allow the tube to be introduced over the screw (Fig. 6). The rotation of the plate and its attachment to the screw is more easily accomplished when treating the elderly

Fig. 3 Anatomical reduction of the fracture with provisional percutaneous stability

Fig. 4 Location of the incision

Fig. 5 Positioning of the 135° guide and introduction of the guide wire

where the muscle is flaccid. Although the plate holes are localised using the external guide, the procedure starts with the drilling, which is done using a distal screw for the proper positioning of the plate under the diaphysis of the femur, thereby preventing a bad alignment. Two distal screws are introduced percutaneously by an accessory 5.0-cm-long entry passage, and the proximal screw is introduced through the principal passage (Fig. 7).

Pre-operative evaluation

In the pre-operative evaluation, patients were submitted to Goldman's evaluation, as reported by Rush in 1968, for clinical condition. Fractures were classified in accordance with Tronzo's criteria. The patient's Ht and Hb were examined, and the patient was asked to indicate his/her intensity of pain on a scale of 0 to 10. All patients were questioned about their ability to move about if using assistance.

Intra-operative evaluation

The operating time was measured from the beginning of anaesthesia until the closure of the skin and for each time the image intensifier was used.

Fig. 6 Introduction of the plate in reversal

Postoperative evaluation

Twenty-four hours following surgery, the patients were asked to once again indicate the intensity of pain on the same scale as that used prior to surgery. The Hb and Ht were also measured. Blood loss was calculated by subtracting the postoperative values from the preoperative one.

The patient was assessed by the principal author at 7, 15, 30 and 60 days following discharge for, wound healing, consolidation of the fracture and ability to walk. Wounds were considered to be healed and with no complications when there was neither hyperaemia nor purulent drainage. At this stage full weight bearing was permitted. The fracture was considered to be consolidated when the patient showed no spontaneous pain, active or passive mobility with no pain and when he/she could bear weight on the fractured limb. Radiographically, the absence of screw migration with or without callus formation were considered to be significant criteria as long as the fracture was clinically united. In the event that the fracture was not consolidated at the 60-day follow-up, the patient would be followed-up at a monthly intervals until the end of the treatment.

The position of the implant was evaluated from pictures taken during postoperative follow-up in the anteroposterior

Fig. 7 Using the external guide for placing the distal screws

Table 1 Mean values of haemoglobin (Hb) and haematocrit (Ht) in patients prior to (pre-op) and following (post-op) surgery

	Pre-op	Post-op	Average
Hb	11.69 g/dl	10.35 g/dl	1.34 g/dl
Ht	35.96%	32.69%	3.27%

>From: Hospital Panamericano de São Paulo SP

and lateral aspects, taking tip-apex distance (TAD) into consideration [3].

Results

Of the 120 medical records analysed, 90 were women and 30 men. The average age of the study cohort was 80 years.

Using Goldman's evaluation, we assessed eight fractures as Type I, 68 as Type II and 34 as Type III. With respect of fracture type, 11 fractures were assessed as Tronzo I, 24 as Tronzo II, 65 as Tronzo III and 20 as Tronzo IV.

Average blood loss expressed as Hb was 1.34 g/dl (range: 0.2–3.7 g/dl). Average blood loss expressed as Ht was 3.27% (range: 0.2–16%) (Table 1). The mean evaluation of pain in the pre-operative stage was 9.62 (range: 8–10). In the post-operative stage, the mean evaluation was 4.44 (range: 2–8).

The mean length of X-ray screening time was 1.07 min (range: 0.6–2.3 min) (Table 2). Mean operating time was 39.35 min (range: 25–65 min) (Table 3).

Seventy-one patients demonstrated signals of consolidation during the first 30 days, 40 within the first 60 days and eight within 90 days.

Of the 120 patients studied, 107 were able to walk with no assistive devices in the pre-operative stage and 13 needed to use some kind of assistance. In the postoperative period, 59 were able to walk without an assistive device, 53 needed a walker and eight could not walk at all.

The mean hospital stay was 3.54 days (range: 2–9 days).

Radiologically, mean TAP in the AP was 1.19 (range: 0.2–1.14). Mean lateral TAP was 1.14 (range: 0.3–2.52).

In terms of the pin's placement, seven were located in the first quadrant, 30 in the second, nine in the third, 18 in the fourth, 28 in the fifth, 11 in the sixth and 17 in the seventh.

Table 2 Fluoroscopy time

Maximum (min)	Minimum (min)	Mean (min)
2.3	0.6	1.07

Table 3 Operating time

Maximum (min)	Minimum (min)	Mean (min)
65	25	39.35

Complications

Of the 120 patients, six showed a loss in reduction which presented as some varus angulation of the fracture with "cut out": five required a total hip replacement (THR) and one was revised for the removal of the material and head of the femur due to infection.

There was two cases of pseudoarthrosis, one with fracture of the sliding pin. One patient was revised for exchange of the pin and plate using a bone graft, which resulted in consolidation. The other patient had THR because of advanced arthrosis. There was also a case of perforation of the femoral head by a protruding pin, which was observed during the postoperative period and subsequently replaced.

There were three deaths: two from an acute myocardial infarct before the sixth month of the postoperative period, and one from a cerebrovascular event during the hospital stay.

Discussion

The best treatment for transtrochanteric fractures of the femur, with due consideration to the instability of the fracture, is still controversial. The discussion over the use of intramedullary sliding screws, such as the proximal femur nail (PFN), Gamma Nail versus the extramedullary sliding screw (DHS), is based not only on their stability, which their proponents advocate on the basis of their shorter lever arm [1, 2], but also on certain biological advantages that include a reduction of bleeding with the use of smaller incisions [2, 15] which, in turn, result in a shorter period of hospital stay and a faster recovery. Several studies have compared intramedullary stems and DHS and have not found significant difference related to operating time, blood loss, consolidation of the fracture and postoperative morbidity [4, 9, 16].

We report here our use of a new minimally invasive technique with a 3-cm skin incision using extramedullary sliding screw, the MINUS System. The acquisition of this new technique necessitates a learning curve for although it has some similarities with the older technique, the minimal size of the incision may impose obstacles to surgery, leading to errors that can compromise bone stability.

The determination of the incision is unusual in that it must be located in a position which allows not only a good access to the femoral neck but also one to the diaphysis.

This position, as described above, is unique in such operations, and the positioning of the incision elsewhere will hinder the introduction and manipulation of the instruments, resulting in the need for a longer incision, which will reduce the benefits of a minimally invasive technique. It is important to be aware of the fact that the diminutive incision by itself does not determine the minimally invasive technique, as this is based on the careful manipulation of the tissues and the use of special tweezers to prevent unnecessary local trauma.

The success of osteosynthesis according to Kaufer [10] is determined by the reduction and by the good positioning of the sliding pin in the centre of the femoral head. It does not necessarily have to be positioned in the centre of the femoral neck, 1 cm from the medial border of the femoral head, but this position should be aimed for. However, in our studies, the TAD average was 1.19 cm anteroposterior and 1.14 cm lateral. In relation to the neck, we aimed for the centre, but we were able to observe that pins localised medially provided proportionally good stabilisation, probably because in this location it worked as a buttress, mechanically impeding varus angulation of the calcar, as in the case with intramedullar stems [13].

This kind of procedure necessitates the use of radiological screening, but exposure time is no longer than that of the usual surgery. In this study, it was around 1.07 min. In the medical literature we found studies where this time was 4 min with the use of intramedullary systems and 3 min with DHS.

Another relevant aspect is the operating time, which in our study was a mean of 39.35 min from the beginning to the end of anaesthesia. The great saving in time was achieved as a result of the small size of the incision, affecting the approach, haemostasis and wound closure. Blood loss was 1.34 g/dl for Hb and 3.32% for Ht. This blood loss is considered to be small when compared to reports in the literature where it is possible to find blood losses varying from 1.7 g/dl with the use of a nail and from 1.8 g/dl with DHS. We did not use haemostasis throughout all surgical procedures for we did not think it would be necessary because of the low level of bleeding.

Although the procedure had relatively bad results, these occurred in great part from failures related to the reduction of the fracture or to the positioning of the implant – and not to the micro-incision. The micro-incision, as reported in the literature, is proportionally shorter than the normal DHS, and even to the nail, measuring around 8–25% of these other two techniques. It is important to note that in the case of pseudoarthrosis, despite successful reduction and the correct placement of the pin, we believe the failure arose from the migration of the pin, which impeded the impaction of the fragments; this probably occurred because a sliding pin longer than 110 mm was used for a plate with a 16-mm

tube. Consequently, the size of the lever arm prevented sliding. Therefore, when there is need for pins of greater in length than 105 mm, we recommend the use of a plate with a 32-mm tube in order to facilitate the sliding of the pin in the tube.

Functional results are not always as satisfactory as technical results. Koval [12] reported that in 336 patients with prefracture walking ability, only 4% recovered their prefracture mobility, with 40% showing reduced walking ability, 12% becoming household ambulators and 8% becoming unable to walk. In our study of 120 patients with prefracture walking ability, 59% recovered their prefracture mobility with no need for assistive devices, 44.1% became more dependent on crutches or walkers and 6.6% became unable to walk. Not all of the patients in this study had complete access to physiotherapy and rehabilitation, which certainly would have played a part in their recuperation.

The encouraging results of this study and the satisfaction of the patient due to the smaller size of the incision are not the most important expressions of the success of the MINUS System for our belief in its efficiency. In addition, there is the cost factor, which is expressed in a shorter hospital stay, the redundancy of electrocautery, the minimum need for blood transfusion and the rapid rehabilitation of the patient. All of these factors give us reason to believe that this minimally invasive surgery is the best option, not forgetting the importance of a stable synthesis for the treatment of transtrochanteric fractures of the femur.

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