Injury, Int. J. Care Injured xxx (2013) xxx–xxx

Contents lists available at SciVerse ScienceDirect

Injury

journal homepage: www.elsevier.com/locate/injury

Technical note

Reverse cutting guidewire for intramedullary nailing: A solution for a common yet undocumented and unresolved complication

Filon Agathangelidis *, Achilleas Boutsiadis, Dimitrios Karataglis, Georgios Petsatodis

1st Department of Orthopaedics, Aristotle University of Thessaloniki, G. Papanikolaou General Hospital, Thessaloniki, Greece

ARTICLE INFO

Article history:
Accepted 1 April 2013

Keywords:
Intramedullary nailing
Guide wire
Reverse cutting
Long bone
Complication

ABSTRACT

In 6 of the 81 patients who were treated with intramedullary nailing for a femoral or tibial fracture the ball-tipped guidewire was impossible to remove manually after nail implantation. In four cases we had to remove the implant and to re-insert the nail. While this is a relatively common complication well known to orthopaedic and trauma surgeons, it has not been previously reported. We developed and tested in vitro a reverse cutting guidewire that was able to successfully deal with this problem obviating the need for implant removal and re-insertion.

© 2013 Elsevier Ltd. All rights reserved.

Introduction

Intramedullary nailing has become the gold standard in the treatment of diaphyseal fractures of the femur and tibia.[1–6] A guidewire is introduced in the proximal part of the fracture and through indirect or direct reduction is passed to the distal part. A ball-tipped guidewire is used in order to avoid unwanted penetration of the bone. In some older-design nails like the Russel-Taylor tibia nail, exchange of the guidewire with the use of a medullary exchange tube was necessary since the diameter of the tip of the ball-tipped guidewire was larger than the inner diameter of the nail. This is unnecessary with newer-design nails like the Trigen (Smith and Nephew, Memphis, Tennessee) or Expert tibial and femoral nail (Synthes, Paoli, PA) where according to the surgical technique the nail is introduced over a 3.2 ball-tipped guidewire.

A relatively common but not previously described complication is the inability to remove the guidewire through the inserted intramedullary nail. In these cases it is necessary to remove both the nail and the guidewire, leading to loss of reduction and repetition of all stages of the procedure from the beginning. The purpose of this study is not only to present this complication but also to propose an innovative solution.

Materials and methods

Between September 2008 and June 2012 eighty-one patients underwent intramedullary nailing of the femur or the tibia in our institution for extra-articular fractures using the Expert femoral or tibial nail. In six cases (7.4%) the ball-tipped guidewire was impossible to withdraw by means of hand manipulation after nail insertion. In two cases hammer blows on the T-handle were successful, while in the remaining four cases the nail (one femoral, three tibial) had to be removed. Following nail removal, it was made evident that a bone fragment was incarcerated between the nail and the guidewire leaving no space for the ball-tip to withdraw through the nail (Figs. 1–4).

A modified reverse-cutting ball-tipped guidewire was developed by our team and was tested in vitro in order to overcome this previously undocumented and unresolved complication.

Two 3.2 guidewires were modified with the use of a high-speed rotary power tool. Using a cutting disc the smooth proximal part of the ball-tip was carved. This resulted in a reverse cutting ball-tip in a fashion similar to the cutting edges of a drill bit (Fig. 5). The direction of the cutting edges was such that clockwise rotation of the guidewire with a power tool would cut through and remove any bone fragment.

In vitro testing of the device was performed. In the first set of tests an Expert tibial nail (Synthes) 9 mm in diameter was used. A fresh arthritic femoral head which was removed from a patient during total hip replacement was used to create a bone fragment hard enough to simulate a young patient's bone. The fragment was impacted with a graft impactor between the tip of the nail and the guidewire (Fig. 6). During the first phase of the test every effort was

* Corresponding author at: Str. Sarafi 39A street, 55132 Kalamaria, Greece. Tel.: +30 6974072836; fax: +30 2310451195.
E-mail addresses: fagath@gmail.com (F. Agathangelidis), mpoutsia@yahoo.gr (A. Boutsiadis), dkarataglis@yahoo.gr (D. Karataglis), gpetsatodis@yahoo.com (G. Petsatodis).

0020–1383/$ – see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.injury.2013.04.002

Please cite this article in press as: Agathangelidis F, et al. Reverse cutting guidewire for intramedullary nailing: A solution for a common yet undocumented and unresolved complication. Injury (2013), http://dx.doi.org/10.1016/j.injury.2013.04.002

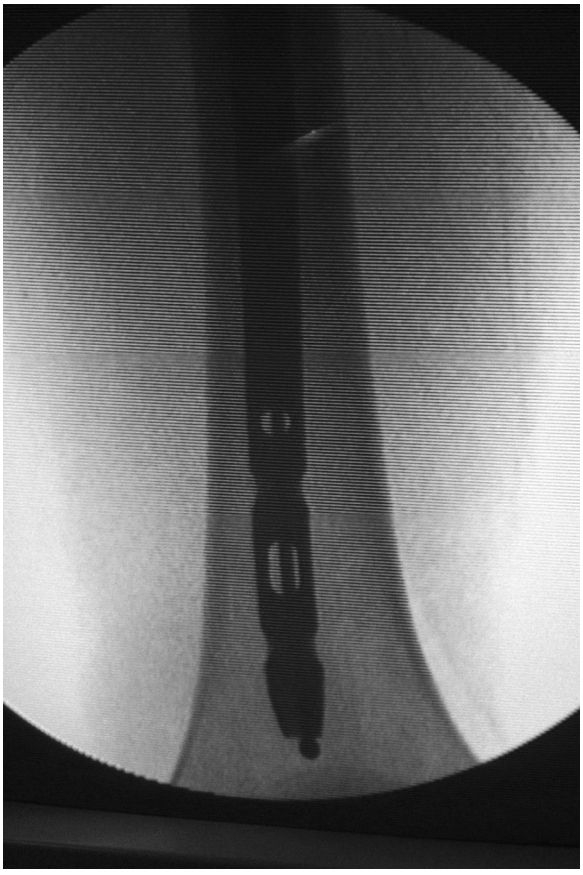

Fig. 1. Case 1: image intensifier image showing the ball-tip of the guidewire protruding from the femoral nail. It was impossible to withdraw the guidewire at the time.

made to remove the wire by hand or reverse hammer blows. When these efforts were unsuccessful we proceeded with the second phase of the test where the guidewire was mounted to a power drill and was withdrawn while rotated clockwise.

In a second set of tests a KFn femoral nail (Königsee Implantate, Allendorf, Germany) with a diameter of 12 mm was used. In a similar manner a polyethylene syringe cap was impacted between the nail and the guidewire (Fig. 7). The ball-tip was impossible to pass through the narrow tip by hand or hammer blows.

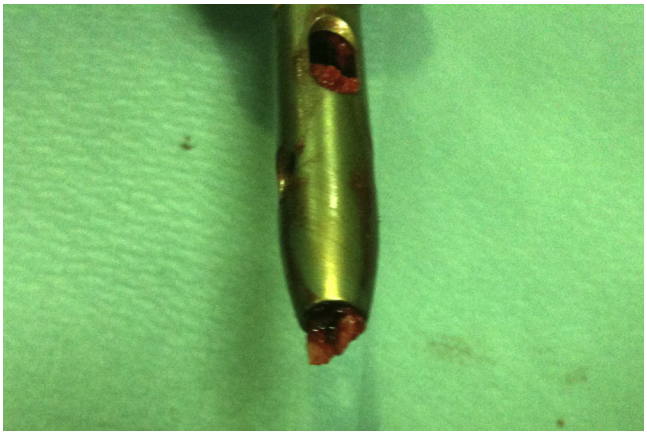

Fig. 2. Case 1: the femoral nail after it was removed. A bone fragment is shown incarcerated at the tip.

Fig. 3. Case 1: the removed bone fragment which was obstructing the ball-tip of the guidewire.

Fig. 4. Case 2: a bone fragment similar to the first case, this time from a tibial nail.

Results

In the first series of tests with the Expert nail we prepared twenty bone fragments that were impacted at the tip of the nail. In fourteen tests the guidewire was withdrawn either by manual force or hammer blows. In the remaining six we managed to simulate the condition in theatre where no manipulation was able to extract the guidewire. In these instances withdrawal with the power drill was effortless. The cutting edges of the modified guidewire easily cut through the bone.

Fig. 5. Close-up image of the reverse cutting guidewire tip.

Please cite this article in press as: Agathangelidis F, et al. Reverse cutting guidewire for intramedullary nailing: A solution for a common yet undocumented and unresolved complication. Injury (2013), http://dx.doi.org/10.1016/j.injury.2013.04.002

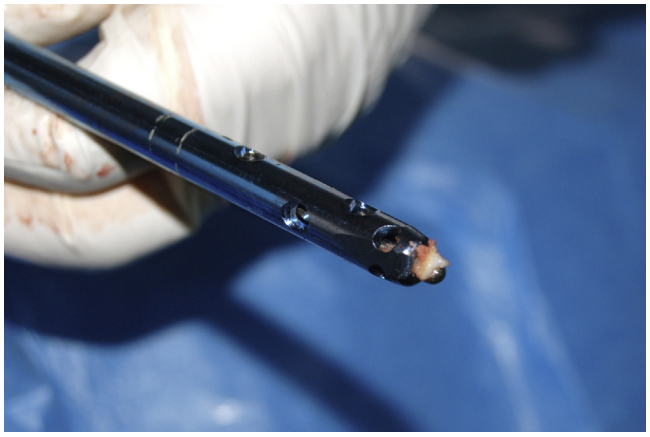

Fig. 6. The Expert tibial nail with a bone fragment impacted at the tip.

Fig. 7. The KFn femoral nail with the syringe cap in place creating a narrow canal.

In the second series ten tests were performed where the ball-tip was impossible to pass through the narrow canal of the syringe cap. When mounted to the drill it passed with little effort in all instances.

Discussion

Various complications have been reported during intramedullary nailing of long bone fractures, including entry point problems, problems with reaming, bending of the nail, iatrogenic fractures or fracture-site comminution, distraction of the fracture site, extrusion of the nail in the adjacent joints or into the soft tissues and neurovascular injuries.[7–9]

Guidewire complications during intramedullary nailing have been described in the past. Faraj et al.,[7] treated a patient with ankle stiffness following tibial nailing and found that the guidewire had penetrated both the talus and calcaneus. They presumed that this happened by the blocked guidewire during nail insertion. Rajappa et al.,[8] documented a similar complication. The intramedullary nail was blocked during its insertion on the straight guidewire, due to an incarcerated small cortical bone fragment. Nevertheless, the result was again the penetration of the ankle joint from the guidewire.

Although the complication we describe is well known amongst experienced trauma surgeons and implant technicians, it has not been documented in the English literature or the surgical technique leaflets of the popular intramedullary implants. It is most likely that the bone fragment is impacted in the tip of the nail while it passes through the fracture site. To our best knowledge, this is the first time that this complication is documented in detail. It is also the first time a reverse cutting ball-tipped guidewire is developed in order to address this complication. It is a safe and efficient way to resolve this problem when it occurs.

Conflict of interest statement

None declared.

Acknowledgement

The authors would like to thank Mrs Eleftheria Papadopoulou, operating theater nurse, for helping with the experimental setup.

References

1. Alho A, Benterud JG, Hogevold HE, Ekeland A, Stromsoe K. Comparison of functional bracing and locked intramedullary nailing in the treatment of displaced tibial shaft fractures. *Clin Orthop Relat Res* 1992;**277**:243–50.
2. Alho A, Ekeland A, Stromsoe K, Folleras G, Thoresen BO. Locked intramedullary nailing for displaced tibial shaft fractures. *J Bone Joint Surg Br* 1990;**72**:805–9.
3. Finkemeier CG, Schmidt AH, Kyle RF, Templeman DC, Varecka TF. A prospective, randomized study of intramedullary nails inserted with and without reaming for the treatment of open and closed fractures of the tibial shaft. *J Orthop Trauma* 2000;**14**:187–93.
4. Henley MB, Chapman JR, Agel J, Harvey EJ, Whorton AM, Swiontkowski MF. Treatment of type II, IIIA, and IIIB open fractures of the tibial shaft: a prospective comparison of unreamed interlocking intramedullary nails and half-pin external fixators. *J Orthop Trauma* 1998;**12**:1–7.
5. Schandelmaier P, Krettek C, Rudolf J, Kohl A, Katz BE, Tscherne H. Superior results of tibial rodding versus external fixation in grade 3B fractures. *Clin Orthop Relat Res* 1997;**342**:164–72.
6. Schmidt AH, Finkemeier CG, Tornetta III P. Treatment of closed tibial fractures. *Instr Course Lect* 2003;**52**:607–22.
7. Faraj AA, Johnson VG. Penetration injury of the hindfoot following intramedullary nail fixation of a tibial fracture. *Acta Orthop Belg* 2002;**68**:178–81.
8. Rajappa S, Kumar NS. Unusual complication following intramedullary nailing of tibia: a case report. *Cases J* 2009;**2**:7343.
9. Watson-Jones R, Bonnin JG, King T, Palmer I, Smith H, Vaughan-Jackson OJ, *et al.* Medullary nailing of fractures after fifty years; with a review of the difficulties and complications of the operation. *J Bone Joint Surg Br* 1950;**32-B**:694–729.

Please cite this article in press as: Agathangelidis F, et al. Reverse cutting guidewire for intramedullary nailing: A solution for a common yet undocumented and unresolved complication. Injury (2013), http://dx.doi.org/10.1016/j.injury.2013.04.002