Journal of Zhejiang University-SCIENCE B (Biomedicine & Biotechnology)
ISSN 1673-1581 (Print); ISSN 1862-1783 (Online)
www.zju.edu.cn/jzus; www.springerlink.com
E-mail: jzus@zju.edu.cn

Letters:

Open wedge re-correction high tibial osteotomy in an elderly patient with a varus angulated non-united dome-shaped high tibial osteotomy

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Received Feb. 19, 2013; Revision accepted June 23, 2013
Crosschecked Oct. 3, 2013

doi:10.1631/jzus.B1300050
Document code: A **CLC number:** R641

The high tibial osteotomy (HTO) is a well-established and commonly used treatment for younger and active patients with a medial unicompartmental osteoarthritis of the knee and varus malalignment. The aim of this technique is to shift the load to a functional lateral compartment in order to delay total knee arthroplasty.

The dome-shaped HTO was introduced by Blaimont *et al.* (1975) and later popularized by Maquet (1980). Out of 118 cases, 96 cases of overcorrection, 13 cases of undercorrection, and 9 cases with anatomical axes have been reported. After undercorrection, the results were poor or fair in 77% (Hsu, 1989). Despite a complication rate of 35% (thrombophlebitis, necrosis of the extensor hallucis longus, tibial plateau fracture, pin tract infection, over- and undercorrection), the results of the dome-shaped HTO showed good or excellent results in 87% (n=40) of the cases (Krempen and Silver, 1982). Sundaram *et al.* (1986) confirmed the good results of the dome-shaped osteotomy. The infection rate at the osteotomy side was 7.6%. A delayed union and bone grafting were noticed in 5.7% of the cases. The staples had to be removed in 8.6% of the cases for various reasons. In 14.3% of the cases, complications at the fibula osteotomy (weakness of the extensor hallucis longus in 3 cases, paraesthesia in 4 cases) have arisen. King-Martinez *et al.* (2007) noted a complication rate of 53% after a dome-shaped HTO.

Meanwhile, the open wedge HTO with the TomoFix™ plate, which was introduced by Staubli *et al.* (2003), has become a widespread surgical technique (Lobenhoffer and Agneskirchner, 2003; Niemeyer *et al.*, 2008; 2010; Takeuchi *et al.*, 2008; 2009; Schröter *et al.*, 2012; Floerkemeier *et al.*, 2013). Only some publications of revision surgery after failed osteotomies are available today (Tsuda *et al.*, 2004; Teitge and van Heerwarden, 2008; Watanabe *et al.*, 2008). In some of these papers, the TomoFix™ plate was used. The use of the open wedge technique with the TomoFix™ plate in non-united dome-shaped osteotomy, as it is described in this article, is an absolute novelty.

In this study, we reported a 74-year-old woman with a medial unicompartmental osteoarthritis of the knee and a varus malalignment, who underwent a dome-shaped HTO with an external fixator in another hospital. A complication (pin infection) occurred in the postoperative progress. The removal of the external fixator was necessary before bone healing and a femoral cast was applied. Full weight-bearing was not possible and the patient needed two crutches to walk.

Six years after the first surgery, the woman came to our outpatient clinic. The patient was able to walk only a few meters on crutches, then she complained of pain in the knee. A physical examination revealed a limited range of motion of the knee joint of 0°/10°/110°. The soft tissue was a little swollen and the scars were free of irritation. In the frontal plane,

the knee ligaments appeared to be insufficient while in the sagittal plane they appeared to be stable. The full weight-bearing long-standing anteroposterior radiograph of the whole lower extremity (Fig. 1), as well as the anteroposterior and lateral view radiographs of the knee (Fig. 2), showed a mechanical tibiofemoral angle (mTFA) of −28° varus (mechanical axis deviation (MAD) −61%) as well as a hypertrophic non-union.

Fig. 1 Full weight-bearing long-standing anteroposterior radiograph of the whole lower extremity
Mechanical tibiofemoral angle (mTFA) of −28° varus (mechanical axis deviation (MAD) −61%); mechanical medial proximal tibial angle (MPTA) 62.4°; hypertrophic non-union at the dome-shaped osteotomy

Fig. 2 Radiograph: anteroposterior (left) and lateral (right) preoperative views
Hypertrophic non-union at the dome-shaped osteotomy

For the surgical planning, the planning software mediCAD Version 2.2 (Hectec GmbH, Niedervie-hbach, Germany) was used. The aim of correction was an mTFA of 0°. During the surgery, the patient was in general anaesthesia. A tourniquet of 450 mmHg at the thigh was used to reduce blood loss in the elderly patient. An anteromedial oblique skin incision was performed. The surgical technique consisted of the removal of the hypertrophic non-union tissue. The osteotomy site was slowly widened up to 20 mm. The osteotomy gap and the defect of the non-union were filled with three tricortical wedge-shaped bone blocks with a wedge-base of 20 mm that had been harvested from the ipsilateral iliac crest. The tricortical bone wedges were placed into the osteotomy gap from medial. Next, the fixation was performed by using the TomoFix™ plate with 5.0-mm locking screws (LS) in holes A–C (proximal holes of the plate are named A–D) and with 4.5-mm bicortical screws in holes 1–4 (distal holes of the plate are named 1–4) (Fig. 3). Finally, the layers were closed and a drain was placed. Postoperatively, the patient was allowed a partial weight-bearing of 20 kg on the side of the surgery. No brace or cast was used. Active physiotherapy started after the removal of the drains.

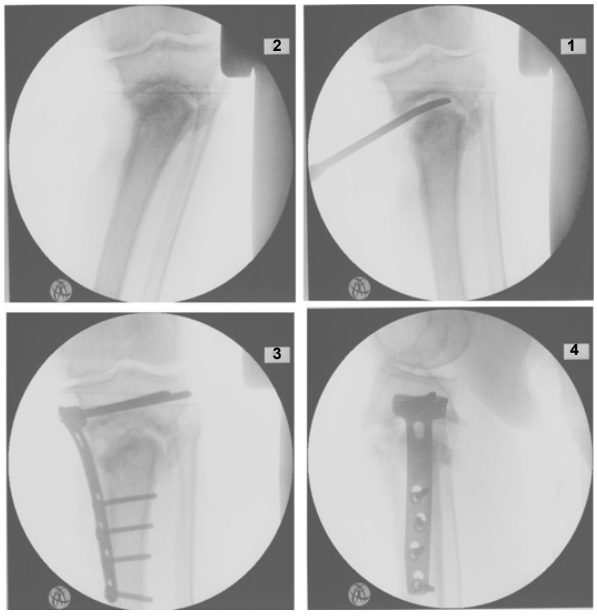

Fig. 3 Fluoroscopy: removing tissue from the non-union and fixation with the TomoFix™ plate with 5.0-mm locking screws in holes A–C and 4.5-mm bicortical screws in holes 1–4
Proximal holes of the plate are named A–D and distal holes of the plate are named 1–4

Four weeks after the surgery, the patient still walked on crutches with a partial weight-bearing of 20 kg. The X-ray showed that the TomoFix™ plate was well-positioned. After the physiotherapy, the patient's range of motion had a deficit of 10° in extension and consisted of a flexion of 110°. However, three months after the operation, the patient was able to carry out full weight-bearing and the osteotomy was consolidated. A physical examination revealed that the soft tissue and the scars were free from irritation. The patient was able to walk short distances without crutches and pain. Twelve months after the surgery, the follow-up examination demonstrated that the osteotomy was completely healed. The alignment was measured by using a full weight-bearing long-standing anteroposterior radiograph of the whole lower extremity (Fig. 4).

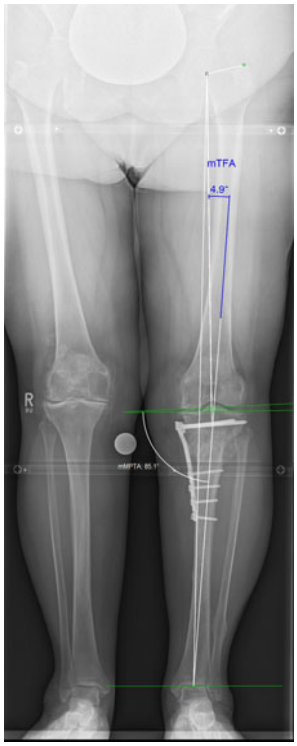

Fig. 4 Full-weight bearing long-standing anteroposterior radiograph of the whole lower extremity
Mechanical tibiofemoral angle (mTFA) of −4.9° varus (mechanical axis deviation (MAD) 25%); mechanical medial proximal tibial angle (MPTA) 85.1°

The mTFA was −4.9° (varus; correction angle: 23°). The medial proximal tibial angle (MPTA) was 85.1°. The range of motion was of 110° in flexion. In extension, however, a deficit of 10° was recorded. The patient was able to walk 30 min without crutches. She was very satisfied with the result.

Until now, no case reports or studies dealing with revision surgery using the TomoFix™ plate after a non-united dome-shaped osteotomy HTO have been published. In this paper, we have presented a surgical technique that allows the treatment of a failed dome-shaped HTO with non-union and severe malalignment. In cases of elderly patients with a non-union and with a malalignment, bone graft from the iliac crest is mandatory to speed up the bone healing. No cast was applied and an early range-of-motion exercise was possible. At the final follow-up, the osteotomy was completely consolidated.

The report by Sundaram *et al*. (1986) about dome-shaped HTO (n=140, follow-up n=105) showed excellent results in 24.8% of the cases, and even 48.6% of the patients were satisfied after the procedure. The aim of a postoperative anatomical tibiofemoral angle (aTFA) was 7° valgus and a postoperative aTFA of 5°–9° valgus as a good correction was assessed. Only 18 out of the 105 participants ended up in this range. Nevertheless, some complications were also reported: 5.7% of the patients showed a delayed union with the need for bone transplantation and four osteotomies failed completely. One patient with a revarization was treated with a knee replacement. The case that has been presented above proves that a re-correction osteotomy can be a successful treatment and that a knee replacement can be successfully prevented.

Tsuda *et al.* (2004) presented an open wedge HTO as a revision of a failed lateral closed wedge HTO. In contrast to the case that is presented here, they had treated a patient with a consolidated osteotomy at the tibia. Furthermore, their patient had a broken medial hinge which resulted in malunion. Osteoarthritis was limited and the age of the patient was 52 years at the time of revision. The indication for recorrection osteotomy was absolutely clear. An open wedge HTO with a spacer plate and bone graft was successfully used. Watanabe *et al.* (2008) reported a recorrection with external fixator (Taylor spatial frame) in case of malunion after lateral closed wedge HTO. The external fixator with a hexapod system is difficult to use in elderly patients. Alternative treatment in elderly patients is a knee replacement. A stemmed total knee prosthesis would require treatment in case of a non-union. Risks of loss of blood and infection during such a surgery would be

considerably higher than those in the presented surgical technique.

The biplanar open wedge HTO is a surgical technique that has been developed to avoid complications like peroneal nerve palsy (Lobenhoffer and Agneskirchner, 2003; Staubli *et al.*, 2003). Even special implants have been developed (Lobenhoffer and Agneskirchner, 2003; Lobenhoffer *et al.*, 2004; Stoffel *et al.*, 2004; Prix, 2005; Asik *et al.*, 2006; Orsel *et al.*, 2006). The biplanar osteotomy is based on an L-shaped cut at the tibial head in the horizontal and vertical directions. By using the TomoFix™ plate, a fixation without cancellous bone transplantation has become possible (Lobenhoffer and Agneskirchner, 2003; Staubli *et al.*, 2003). Biomechanical investigations in sawbone models showed a high primary stability with a limit of 1606 N in axial load (Agneskirchner *et al.*, 2006). In our case, a biplanar osteotomy after the failed dome-shaped HTO was not possible due to the non-union in the dome-shaped osteotomy. In cases of non-union, a bone graft is mandatory, especially in elderly patients. Based on the high biomechanical quality of the implant, a partial weight-bearing was possible and satisfying clinical and radiological outcomes could be achieved. Furthermore, a knee replacement could be prevented. Today, revision surgery in osteotomy is still a procedure that is reserved for orthopaedic surgeons with much experience in osteotomy.

Open wedge HTO for revision surgery with an autologous bone graft from the iliac crest and fixation with the TomoFix™ plate can be performed as a revision surgery after a failed dome-shaped HTO. Even in elderly patients, the clinical result can be satisfactory and the procedure is a very good treatment to prevent knee replacement.

Acknowledgements

The authors express their gratitude to the patient who made this case report possible by giving her agreement.

Compliance with ethics guidelines

Steffen SCHRÖTER, Lukas KONSTANTINIDIS, Tobias M. KRAUS, Fabian STUBY, Ulrich STÖCKLE, and Thomas FREUDE declare that they have no conflict of interest.

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000(5). Informed consent was obtained from all patients for being included in the study.

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