



Technical note

Failed high tibial osteotomy: A joint preserving alternative to total knee arthroplasty

Gareth G. Jones*, Susannah Clarke, Martin Jaere, Justin P. Cobb

MSK Lab, Imperial College London, Charing Cross Hospital, 7th Floor Lab Block, W6 8RF London, UK



ARTICLE INFO

Article history:

Received 16 May 2018

Accepted 5 November 2018

Keywords:

Patient specific instrumentation

3D printing

High tibial osteotomy

Revision arthroplasty

Unicondylar knee arthroplasty

ABSTRACT

High tibial osteotomy is an attractive treatment option for young active patients wishing to return to high-level activities. However, it is not considered a long-term solution, with 30% revised at ten years. Currently, the only revision option is a total knee arthroplasty, a procedure that might not deliver the functional level expected by these highly active patients. This paper describes a novel joint preserving approach to HTO revision, using assistive technology, in the form of 3D printed guides, to reverse the osteotomy and simultaneously perform a unicondylar knee replacement. The indications and planning aims for this procedure are discussed, and the preliminary results in four patients presented.

Level of evidence: IV.

© 2018 Published by Elsevier Masson SAS.

1. Introduction

High tibial osteotomy (HTO) is an attractive option in younger, physically active patients with symptomatic cartilage loss and varus malalignment [1]. However, it has a revision rate of approximately 30% at ten years, attributable either to progressive arthrosis in the medial tibiofemoral compartment, or development of arthrosis in the lateral or patello-femoral compartments [1,2].

Currently, the only revision option for a failed HTO is a total knee arthroplasty (TKA). Compared to primary TKA, both equivalent and inferior outcomes have been reported [3,4]. Irrespective of this, in younger active patients, such as those requiring revision post-HTO, a primary TKA is still associated with significant levels of dissatisfaction and higher revision rates [5,6]. Unicondylar knee arthroplasty (UKA) would be an attractive alternative in patients with progressive medial tibiofemoral compartment arthrosis, but is avoided due to the altered mechanical alignment, abnormal tibial joint line obliquity, and distorted soft tissue tension post-HTO [7,8].

This paper presents the early results of a novel joint preserving approach to HTO revision surgery, that uses the assistive technology of patient specific instrumentation (PSI), to reverse the previous osteotomy and perform a medial UKA.

2. Technique

Suitable patients have valgus alignment and isolated progressive medial tibiofemoral compartment arthrosis post-HTO. A CT derived 3D bone model of the hip knee and ankle is matched to a weight-bearing long leg radiograph (or EOS scan) to produce a virtual 3D weight-bearing model [9]. For consistency, this model is then aligned in space using established frames of reference [10], before computer aided design (CAD) software is used to plan an osteotomy that reverses the prior osteotomy e.g. a closing wedge to reverse a medial opening wedge osteotomy (Fig. 1) or an opening wedge to reverse a lateral closing wedge osteotomy. Two criteria need to be satisfied: (1) the medial proximal tibial angle (MPTA) is returned to within the normal range (85–90°), and (2) the hip-knee-ankle (HKA) is restored to approximately 4° varus, which is normal for patients with constitutional varus [11]. If necessary, the anatomic posterior proximal tibial angle (PPTA) can also be corrected.

The 3D bone model incorporating the osteotomy reversal is then used to plan the position of a medial UKA in a standard fashion, using validated 3D planning software (Acrobot, London). A novel patient specific guide (Embodiy, London), 3D printed in medical grade nylon, is designed to match the contour of the patient's proximal tibia and malleoli, and guide the surgeon in performing the saw cuts for the UKA tibial component, and osteotomy (Fig. 2). The UKA tibial cut and insertion of the tibial component is performed first, in order to avoid fracture of the osteotomy hinge. Osteotomy angular correction is confirmed intra-operatively using a personalised guide prior to plate fixation.

* Corresponding author.

E-mail address: ggjones@imperial.ac.uk (G.G. Jones).

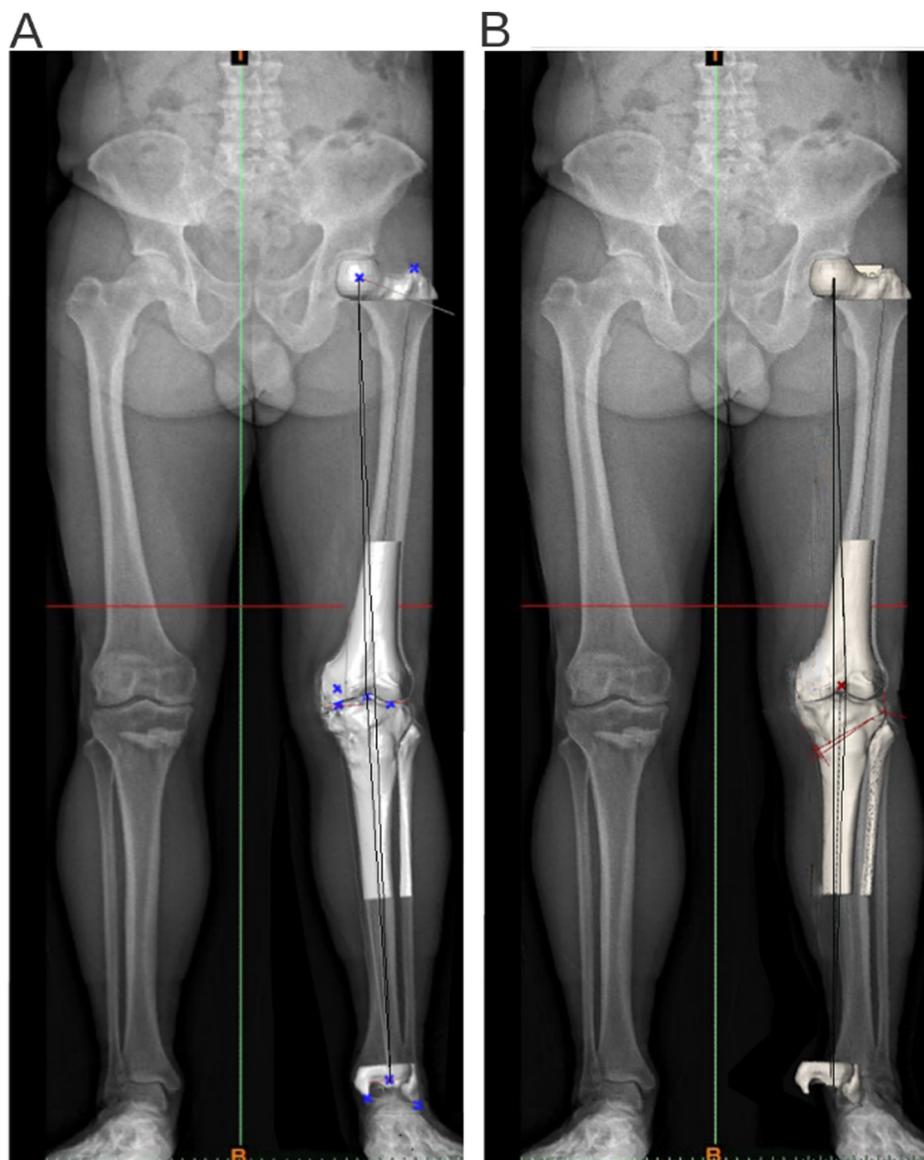


Fig. 1. Preoperative planning for a patient who developed progressive left medial compartment arthrosis after previously undergoing bilateral opening wedge HTOs. A. A 3D bone model of the left leg is orientated and matched to a weight-bearing EOS scan. MPTA 92°, HKA 184°, PPTA 9°. B. Predicted leg position after the planned corrective closing wedge osteotomy. MPTA 87°, HKA 176°, PPTA 9°.



Fig. 2. A Nylon 3D printed patient specific guide for the UKA and osteotomy reversal.

UKA femoral component positioning and soft tissue balancing is then performed using conventional instruments (Fig. 3).

3. Results

We have used this technique to treat four patients (two medial closing wedge osteotomies and two lateral opening wedge osteotomies) with follow-up at one year. A medial cementless Oxford UKA (Zimmer Biomet, Bridgend, UK) was used in all cases. There were no complications. Radiographic and patient reported outcomes are detailed in Table 1.

4. Discussion

To our knowledge, this is the first report of combined osteotomy and unicompartamental knee arthroplasty for the treatment of a failed HTO. Our pilot series of four cases demonstrates encouraging results, with a mean postoperative OKS of 40, which compares favourably with primary UKA results from both the UK (mean 37.7, 95% CI 37.4 to 38.0) and New Zealand (mean 37.0, range 8.0–48.0) joint registries [7,13].

Notwithstanding the fact that these results need to be interpreted with caution given the small number of patients involved, and the relatively short follow-up, we suspect that restoration of a normal oblique tibial joint line (MPTA < 90°), that returns the leg to its pre-morbid varus alignment, is important for the success of a UKA in this patient population. If revision to a TKR is ever required, a corrected MPTA will also allow for a more bone preserving saw cut, and reduce the risk of patella infera, and tibial stem impingement on the lateral cortex.

The technique we have described facilitates the concept of an ‘arthroplasty ladder’ for young active patients with varus alignment



Fig. 3. Anteroposterior radiograph of the patient in Fig. 1 at 12 weeks postoperative.

and arthrosis, with the aim of delivering an age appropriate level of pain relief and function, whilst also reducing the risk of a revision TKA during their lifetime (Fig. 4).

Using assistive technology to perform novel operations represents a paradigm shift in knee surgery. The technically challenging procedure we have described is made possible by the use of 3D pre-operative planning, and a 3D printed patient-specific guide that controls osteotomy position, degree of angular correction, and orientates the saw-cuts for a unicompartmental prosthesis according to the corrected leg alignment. Whilst conventional instrumentation is unlikely to deliver the required level of accuracy and

Table 1
Radiographic and patient reported outcomes.

	Preoperative	Postoperative	p-value
Patient reported			
Oxford Knee Score (OKS)	24 (3)	40 (5)	0.001
EQ-VAS	65 (7)	85 (6)	0.017
Radiographic			
MPTA	92° (2°)	85° (3°)	0.029
PPTA	81° (3°)	83° (1°)	0.182
HKA	-2° (1°)	3° (1°)	0.012
IS Index	0.9 (0.1)	1.0 (0.1)	0.182

Results are given as means (standard deviation). Radiographic measurements performed according to the methods described by Dror Paley [12]: MPTA (medial proximal tibial angle), PPTA (anatomic posterior proximal tibial angle), HKA (hip-knee-ankle angle). IS Index (Insall-Salvati Index). Paired t-test used for comparisons.

precision, other forms of assistive technology (e.g. robotics) might do so. We suggest that this joint preserving approach should be considered as a treatment option for suitable patients who once merited a HTO. A randomised controlled trial to compare results with TKA is warranted.

Ethical review committee statement

All participants gave written informed consent, and ethical approval for the project was granted by the National Research Ethics Service (Stanmore, London, UK - REC Reference: 13/LO/1639). All procedures were performed in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Funding sources

G. Jones declares grants from The Frances and Augustus Newman Foundation, and from The Michael Uren Foundation, activity relating to the submitted work.

J. Cobb declares grant funding from the Michael Uren Foundation, activity relating to the submitted work; patents and stocks/stock options for Embody Orthopaedic, activity outside the submitted work.

Authors' contribution

G.G. Jones—study design, data acquisition, interpretation and preparation of manuscript.

S. Clarke—study design and preparation of manuscript.

M. Jaere—study design and preparation of manuscript.

J.P. Cobb—study design, interpretation and preparation of manuscript.

All authors have approved the final version of this manuscript.

Disclosure of interest

S. Clarke declares provision of equipment from Embody Orthopaedic, activity relating to the submitted work; board membership, royalties and stocks/stock options from Embody Orthopaedic, activity outside the submitted work.

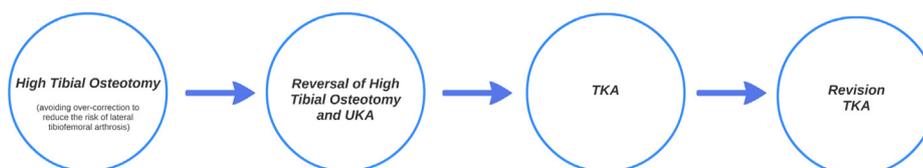


Fig. 4. Proposed 'arthroplasty ladder' for young patients with varus gonarthrosis.

M. Jaere declares consultancy for Embody Orthopaedic, activity outside the submitted work.

References

- [1] Spahn G, Hofmann GO, von Engelhardt LV, Li M, Neubauer H, Klinger HM. The impact of a high tibial valgus osteotomy and unicompartmental medial arthroplasty on the treatment for knee osteoarthritis: a meta-analysis. *Knee Surg Sport Traumatol Arthrosc* 2013;21:96–112.
- [2] W-Dahl A, Robertsson O, Lohmander LS. High tibial osteotomy in Sweden, 1998–2007. *Acta Orthop* 2012;83:1–5.
- [3] Badawy M, Fenstad AM, Indrekvam K, Havelin LI, Furnes O. The risk of revision in total knee arthroplasty is not affected by previous high tibial osteotomy: a 15-year follow-up of 32,476 total knee arthroplasties in the Norwegian Arthroplasty Register. *Acta Orthop* 2015;86:734–9.
- [4] Parvizi J, Hanssen AD, Spanghel MJ. Total knee arthroplasty following proximal tibial osteotomy: risk factors for failure. *Singapore Med J* 2003;44:554–6.
- [5] Nam D, Nunley RM, Barrack RL. Patient dissatisfaction following total knee replacement: a growing concern? *Bone Joint J* 2014;96-B:96–100.
- [6] Price AJ, Longino D, Rees J, Rout R, Pandit H, Javaid K, et al. Are pain and function better measures of outcome than revision rates after TKR in the younger patient? *Knee* 2010;17:196–9.
- [7] Liddle AD, Pandit H, Judge A, Murray DW. Patient-reported outcomes after total and unicompartmental knee arthroplasty: a study of 14,076 matched patients from the national joint registry for England and Wales. *Bone Joint J* 2015;97-B:793–801.
- [8] Jones GG, Kotti M, Wiik AV, Collins R, Brevadt MJ, Strachan RK, et al. Gait comparison of unicompartmental and total knee arthroplasties with healthy controls. *Bone Joint J* 2016;98-B:16–21.
- [9] Henckel J, Richards R, Lozhkin K, Harris S, Rodriguez Baena FM, Barrett WAR, et al. Very low-dose computed tomography for planning and outcome measurement in knee replacement. The imperial knee protocol. *J Bone Joint Surg Br* 2006;8888:1513–8.
- [10] Cobb JP, Dixon H, Dandachli W, Iranpour F. The anatomical tibial axis: reliable rotational orientation in knee replacement. *J Bone Joint Surg Br* 2008;90-B:1032–8.
- [11] Bellemans J, Colyn W, Vandenneucker H, Victor J. The Chitranjan Ranawat award. Is neutral mechanical alignment normal for all patients? *Clin Orthop Relat Res* 2012;470:45–53.
- [12] Paley D, Pfeil J. Principles of deformity correction around the knee. *Orthopade* 2000;29:18–38.
- [13] Rothwell AG, Hooper GJ, Hobbs A, Frampton CM. An analysis of the Oxford hip and knee scores and their relationship to early joint revision in the New Zealand Joint Registry. *J Bone Joint Surg Br* 2010;92:413–8.