MENTORS IN ORTHOPEDICS

TIBIAL TUBERCLE "CREST" OSTEOTOMY (TCO) A MODIFICATION OF THE CLASSICAL TIBIAL TUBERCLE OSTEOTOMY ALLOWS SAFE AND EASY EXTENSILE KNEE EXPOSURE

https://doi.org/10.71165/bngw-dqqe

AUTHORS

Umar BJ Yousuf - Cardiff and Vale University Health Board, Cardiff, United Kingdom
Rhidian L. Morgan-Jones - University Hospital Llandough, Cardiff, United Kingdom

SUMMARY

Background: Revision total knee arthroplasty requires extensile surgical exposure to ensure component explantation and debridement while maintaining extensor mechanism integrity. Traditional soft tissue procedures may lead to patellar tendon avulsion or extensor lag, while conventional tibial tubercle osteotomy fixation using screws or cerclage wires is frequently associated with hardware-related complications, anterior knee pain, and fragment migration.

Objective: This article describes a modified, low-energy tibial crest osteotomy (TCO) technique utilizing suture fixation to facilitate reproducible surgical access and immediate postoperative mobilization in complex revision knee surgery.

Key Points: The TCO involves a coronal plane osteotomy of the tibial tubercle, typically 6 to 8 cm in length, performed using multiple osteotomes to avoid thermal necrosis. A critical technical requirement is the preservation of the lateral soft tissue sleeve, which acts as a vascularized hinge to promote bone union and provide dynamic stability. Fixation is achieved by reducing the fragment in extension and securing it with heavy non-absorbable braided polyester sutures passed through 2 mm drill holes in the segment and tibial medulla. Clinical data from 181 cases demonstrated a 100% union rate at a mean of 11 weeks, with no reported extensor mechanism failures. The technique allows for immediate weight-bearing and full range of motion without bracing.

Conclusion: Tibial crest osteotomy with ligature closure provides a stable, hardware-free alternative for extensile exposure. By adhering to low-energy principles and preserving lateral vascularity, surgeons can achieve predictable bone healing and excellent clinical outcomes in complex revision scenarios.

KEYWORDS

Arthroplasty, Replacement, Knee; Osteotomy; Tibia; Reoperation; Suture Techniques

INTRODUCTION

There is an increasing demand for revision total knee arthroplasty [1]. Exposure is a critical operative step and can be difficult; struggling for exposure impacts the workflow of the surgery and may lead to prolonged operating time. Faced with these challenges of rising demand and complexity of revision surgery, the arthroplasty surgeon must be equipped with the necessary knowledge and skill to employ safe and reproducible techniques in order to achieve satisfactory patient outcomes. We describe the method of tibial tubercle 'crest' osteotomy (TCO) as developed and used in our institution routinely by the senior author in revision knee arthroplasty. The TCO represents a modification of the classical TTO described by Whiteside long time ago [8].

The ideal extensile approach should ensure the integrity of the extensor mechanism, safe explantation/ implantation, simple postoperative protocol and speedy recovery [2]. Adequate exposure can be achieved through either proximal soft tissue or distal boney procedures. Soft tissue procedures are associated with patella tendon avulsion and marked extensor lag [3]. We believe that proximal soft tissue procedures are a poor choice with significant implications for healing, function and outcome and we find the distally based boney TCO to be a better option for both the patient and the surgeon [4].

A TCO involves the tibial tubercle being osteotomised in the coronal plane. Traditionally, fixation methods that have been described are with screw or cerclage wire. Screw fixation is associated with anterior knee pain and further surgery to hardware, osteotomy segment fracture and shaft fracture. Cerclage wire fixation is associated with anterior knee pain, soft tissue injury by the tying of the wires and proximal migration of the osteotomy segment [5]. The senior author (RM-J) has developed the suture closure of TCO to reduce complications with traditional fixation techniques in revision knee arthroplasty [6]. The four key principles of TCO [7] are as follows:

1. Low energy Avoid the use of a saw and use multiple osteotomes to avoid thermal necrosis. Using this low energy technique allows for an abrasive surface for healing and fixation based on Whiteside's principles [8]

2. Length Long surface contact to improve healing of approximately 6 to 8 cm

3. Lateral sleeve preservation to preserve the integrity of lateral soft tissues that form a 'vascular book hinge.' This muscular sleeve allows dynamic stabilisation of the osteotomy especially preventing proximal escape and the vascular sleeve aids bone union.

4. Ligature (suture) closure following the above principles closure and fixation with 5/0 Ethibond suture facilitates immediate weight bearing, full range of motion without the use of a brace.

For any surgical technique to be repeated successfully in multiple hands, it must have well-defined steps that allow reproducibility during surgery and predictable outcome postoperatively.

TECHNIQUE

Problems with exposure need to be anticipated preoperatively by clinical and radiological assessment. All revision patients are discussed at a multidisciplinary meeting and infected cases are entered in the UK Bone and Joint Infection Registry [9]. All patients undergo a process of informed consent. On the day of surgery, under

appropriate anaesthetic patients are positioned supine with knee side support. After alcoholic skin preparation we prefer to use a sterile non-pneumatic exsanguinating tourniquet maximising operative field space for revisions aiming for an average operative time of 1.5-2 hours at the maximum [10]. Thereafter the following eight steps are undertaken.

A medial parapatellar approach is undertaken. The retinaculum is incised from the apex of the quadriceps tendon to the tibial tubercle. The synovium is debrided. At this stage, the early decision to perform a TCO is taken if patella is not everting or if access is required to tibial component (via the medulla) for explantation or to the posterior knee for debridement. Place the knee in extension in neutral rotation. The crest is defined medially with subperiosteal dissection. If desired the osteotomy line can be marked out using the electrocautery or a surgical marker pen (figure 1).

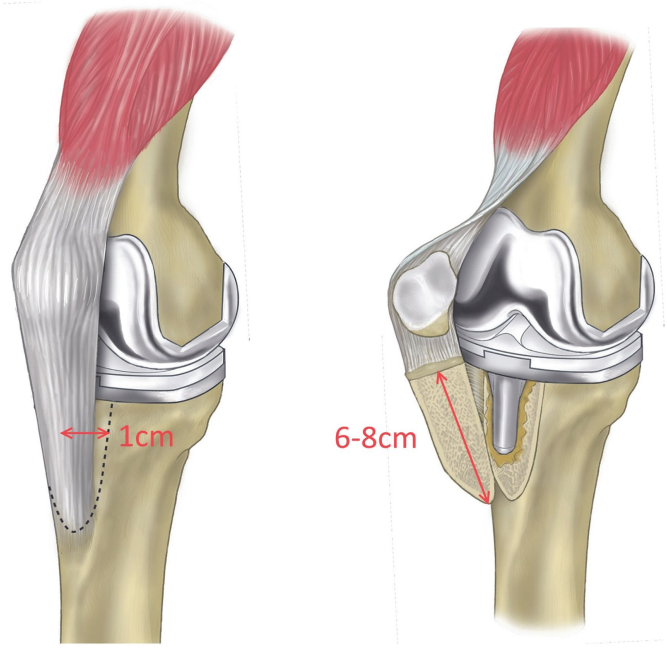

Figure 1. Schematic showing the level and length of the osteotomy. This is an adapted drawing, would it be possible to draw a new schematic please? Adapted from Deane et al 2008 [4]

Firstly, perform a vertical medial cortical osteotomy. Insert the first sharp broad osteotome from superiorly to inferiorly at the level of the anterior lip of the implanted tibial tray in the coronal plane parallel to the floor creating a maximum thickness of approximately 1 cm, aiming to keep the osteotomy between 6-8 cm in length. Care is taken to include the whole insertion of patella tendon. The osteotome is continued until the anterior tibial cortex distally is reached. This osteotome only engages the medial cortex and some of cancellous bone. Depending on the morphology of the tubercle the osteotomy may need to be 'bevelled' obliquely anteriorly at the end to avoid excessive distal propagation- often times this is required in a patient with marked fixed flexion deformity. No proximal or distal steps in the cut are required. Remove this osteotome.

Secondly, perform a horizontal osteotomy (figure 2). Now from the medial side of the tubercle, in a lateral direction insert a sharp broad osteotome superiorly and possibly a second and third osteotome inferiorly adjacent to each other in the osteotomy site carefully impacting and engaging the lateral (far cortex) but no more- the periosteum and lateral structures are to be preserved. The osteotomes are kept in position.

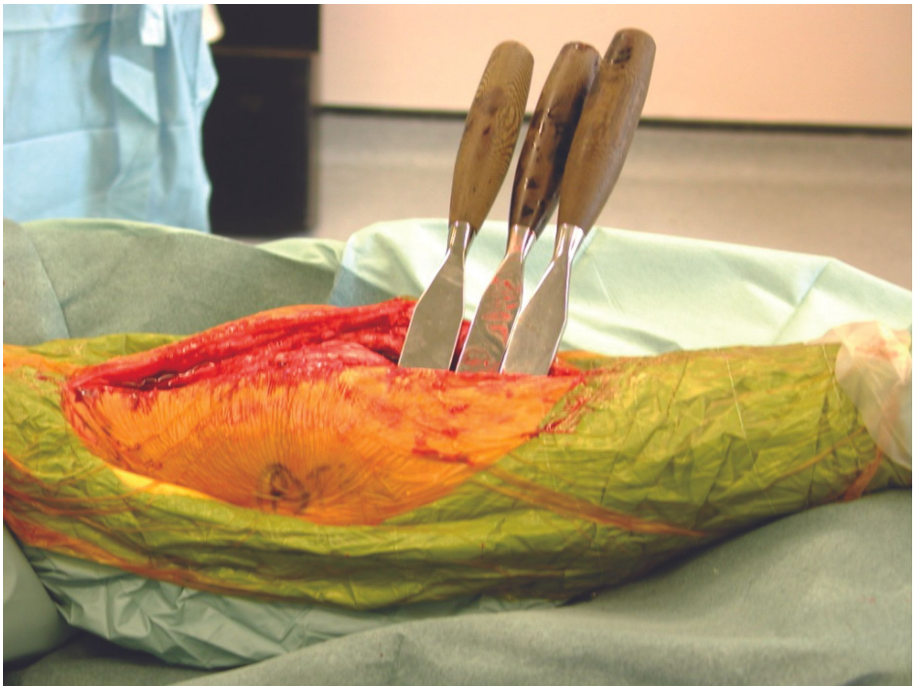

Figure 2. Osteotomes are inserted from medial to lateral to develop the low-energy cut. They are then levered in synchrony to open the osteotomy taking care to preserve the lateral soft tissues.

Open the osteotomy. In synchrony, lever the osteotomes in an anterior direction (towards the ceiling) causing the osteotomy to complete laterally hinging on the lateral soft tissues. The osteotomy site opens. Occasionally the osteotomy will fragment; provided the lateral 'vascular book hinge' is preserved this will not affect union [6]. Evert the osteotomy. Now the osteotomy fragment can be everted with the attached extensor mechanism and the knee can be flexed up with ease.

Set up closure of the osteotomy by drilling holes (figure 3). Once the revision is performed, realignment and attachment are made under direct vision with the segment restored to original position in extension. Typically, it requires three to four 2mm drill holes depending on the length and profile of the segment (three is ideal). Drill these in the osteotomy segment and corresponding into the tibial medulla. The paired drill holes in the tibia and osteotomy segment are located approximately equidistant from the cut line. The positioning of these drill holes is to be made carefully so as to allow a 55mm ½ circle tapercut needle segment to pass from the osteotomy segment to the tibia. Heavy Number 5 Ethibond braided polyester sutures are used to secure the osteotomy.

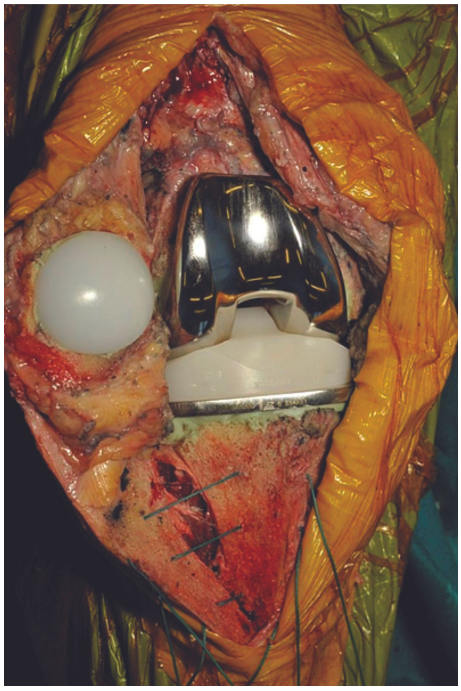

Figure 3. Once the osteotomy is opened the knee can be easily assessed. Note the lateral 'vascular book hinge' have been carefully preserved. The drill holes are carefully placed to aid passing of a 5-0 ethibond suture. 2-4 sutures may be used but 3 is ideal.

Complete closure of the osteotomy by passing sutures (figure 4). For each segment of holes, a suture is passed, clipped and cut. When passing the suture anteriorly on the osteotomy segment, care must be taken to pass this under the patella tendon to avoid strangulation. For 3 sutures, the upper (number 1) and lower (number 3) sutures are held taught with the osteotomy fragment reduced in position by the assistant whilst the surgeon secures the number middle position (number 2), with at least with 3 throws. Then the number 1 and 3 sutures are tired off ensuring the stability of the osteotomy. At this point, the knee can be passed through a range of motion to test the stability of the fixation. Having tensioned the osteotomy in extension, passive knee flexion can be seen to increase compression of the osteotomy site; this is secure fixation. Continue the knee closure as per routine.

Figure 4. Closing the osteotomy in extension ensure it compressed in flexion.

Post-operatively patients are allowed full range of motion and weight bearing with no brace needed. The post-operative radiographs (figure 5) are as per protocol (we advise educating radiologists on the use of the TCO to avoid misreporting). Follow-up regimen does not differ from other revision knee arthroplasty patients.

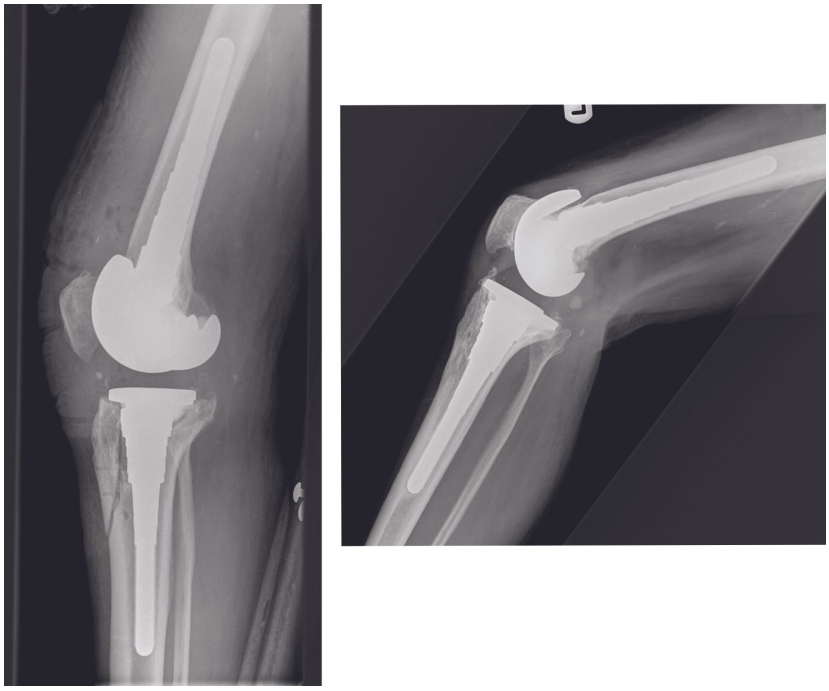

Figure 5. Immediate post-operative (left) and 3 months follow up radiographs (right) with the osteotomy united. Note the position of the dill holes in the top radiograph.

LIMITATIONS AND PITFALLS

Damage to lateral soft tissue hinge. Preservation of the vascular book hinge is a key part of this technique. Any damage to this will compromise the initial stability and subsequent union of the TCO. Care should be taken to ensure the osteotome does no perforate out with the lateral/ far cortex of the TCO.

Stiff TKR with patella Baja. In the context of a revision of a stiff TKR, care must be taken to avoid distal propagation of the TCO. To avoid this bevel the osteotomy anteriorly.

Fragmentation. If the osteotomy is too thin in thickness or the bone is of poor quality, it may fragment. Based on our series 26% of TCO were fragment and this no affect union rate so this is nothing to be overly concerned about [6].

Local discomfort. This is experience for 6-8 weeks but it does not limit movement or weight bearing.

DISCUSSION

Our tibial crest osteotomy (TCO) technique allows unimpeded access to the joint, protects the extensor mechanism, encourages bone-on-bone healing, and avoids symptomatic surgical hardware.

We first proposed ligature fixation technique of TCO in 2008. Subsequently, in our series of 181 TCOs we showed that there was 100% union at mean period of 11 weeks with no extensor mechanism failure or complications related to the suture material at average follow up of 22 months [6]. This has demonstrated the utility of this technique gaining satisfactory outcomes whilst avoiding hardware problems.

Adequate exposure is key in infected cases [11]. In the largest single-surgeon series of single-stage knee arthroplasty revisions for infection all 84 cases had a TCO in order to facilitate surgical debridement of infected tissue. This study showed eradication of infection in 90.5% of patients at 7 years [12]. Of course, the TCO was not the only reason for this excellent eradication rate, but we believe it is an important factor to allow access to the knee especially posteriorly.

CONCLUSION

This technique of TCO with ligature closure provides a reproducible method to improve access in complex revision knee arthroplasty compared with other methods distally that use metalwork with its associated problems and proximal soft tissue methods without compromise of the extensor mechanism. We argue that this technique with well-defined steps is easier to perform as compared with other methods and most importantly allows for safe and expeditious revision surgery without compromising outcomes in a reproduceable way provided the basic principles are adhered to.

REFERENCES

1. Agarwal S, Kabariti R, Kakar R, D'Jon L, R Morgan-Jones (2019). Why are revision knee replacements failing? Knee 26(3) 774-778

2. Abbas A, Razii N, Morgan-Jones R (2019). Extensile Exposure in Revision Total Knee Arthroplasty. In: Mastering Orthopaedic Techniques: Revision Knee Arthroplasty Ed Malhotra R, Gautuam D. Jaypee, New Delhi.

3. Sun Z, Patil A, Song EK, Kim HT, Seon JK (2015). Comparison of quadriceps snip and tibial tubercle osteotomy in revision for infected total knee arthroplasty. Int Orthop. 39(5):879-85.

4. Deane CR, Ferran NA, Ghandour A, Morgan-Jones (2008). Tibial tubercle osteotomy for access during revision knee arthroplasty: ethibond suture repair technique BMC Musc Disorders 9, 98

5. Kitridis D, Givissis P, Chalidis B (2020). Timing of tibial tubercle osteotomy in two-stage revision of infected total knee arthroplasty does not affect union or reinfection rate. A systematic review. Knee 27(6) 1787-1794

6. Abbas AMI, Williams RLL, Khan WS, Ghandour A, Morgan-Jones RL (2016). Tibial crest osteotomy in Extensile knee Exposure-A modified, low-energy, suture technique. J Arthroplasty 31(2):383–388

7. Morgan-Jones R (2021). Infected total knee replacements: how I do a one-stage revision. Knee 28, 422-27

8. Whiteside LA. Exposure in difficult total knee arthroplasty using tibial tubercle osteotomy. Clin Orthop Relat Res. 1995;321:32–35.

9. Bone and Joint Infection Registry (BAJIR). https://bajir.org Accessed April 30 2021

10. Ved A, Kempshall PJ, Sharma H, Morgan-Jones R (2015). A comparison of operative field space between sterile single use and re-usable pneumatic tourniquet in revision total knee arthroplasty. International Journal of Orthopaedic Sciences 1(1): 01-03

11. Khan W, Morgan-Jones R. Debridement: defining something we all do. J Trauma Orthop. 2016;4(1):48–50

12. Razii R, Clutton JM, Kakar R, Morgan-Jones R (2021). Single-stage revision for the infection total knee arthroplasty: the Cardiff experience. BJO 2(5), 305-313