The new “dual osteotomy”: combined open wedge and tibial tuberosity anteriorisation osteotomies

Wael Samir Abdel Megied · Mahmoud A. Mahran ·
Mootaz F. Thakeb · Amr A. K. H. Abouelela ·
Yasser Elbatrawy

Received: 31 October 2009 / Revised: 13 November 2009 / Accepted: 15 November 2009 / Published online: 9 December 2009
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Abstract The high frequency with which medial compartment osteoarthritis is associated with patellofemoral osteoarthritis makes the addition of tibial tuberosity anteriorisation to high tibial osteotomy an appealing solution, despite the discouraging previously reported long-term results when tubercle anteriorisation was combined with a Coventry closed wedge technique. We conducted a prospective study of a new osteotomy combination: “the dual osteotomy”. An open wedge high tibial osteotomy was combined with 1- to 1.5-cm Maquet-like tibial tuberosity anteriorisation. Thirty-four knees in 30 patients underwent surgery, including ten knees in nine male patients and 24 knees in 21 female patients with a mean age of 45 years (age range 34–58 years). All patients had varus medial compartment osteoarthritis and patellofemoral osteoarthritis with preoperative anatomical tibiofemoral angle exceeding 5°. Twenty-four months after surgery, final evaluation detected improvement in the Knee Society clinical rating system function score from a mean of 61.3 (range 30–80) preoperatively to a mean of 87.3 (range 50–100) postoperatively and in the knee pain score from 27.3 (range 10–30) to 47 (range 30–50) postoperatively. Based on the rating system, at final follow-up, 70% of patients experienced no pain, 13% had mild or occasional pain, 10% had pain on stairs only, and 7% had pain during walking and on stairs. Anatomical tibiofemoral

angles from 0 to 10° valgus were achieved in 91% of operated knees, and union was achieved in all cases within six to twelve weeks after surgery. The dual osteotomy was effective in the short term in cases of medial compartment osteoarthritis associated with patellofemoral osteoarthritis.

Introduction

Osteoarthritis (OA) commonly affects the knee with predilection to the medial compartment, making varus alignment the most common deformity. Several surgical treatment options exist, including arthroscopic debridement and lavage, abrasion arthroplasty, transplantation of large osteochondral autograft, unicompartmental knee arthroplasty, high tibial osteotomy (HTO), and total knee arthroplasty [28]. HTO has become an accepted technique, especially in cases of varus medial compartment osteoarthritis (MC-OA). Lateral shifting of the weight-bearing axis spares the lateral compartment [7, 8]. Results in the literature vary, but overall, the mid- and long-term results are good when the correct technique is used in a properly selected patient population [1, 19]. HTO can be performed as a Coventry closed wedge (CWHTO) [6, 10], dome [5, 13], open wedge (OWHTO) [1, 5, 7, 19] or combined open and closed wedge osteotomy [14]. Despite the lack of high levels of evidence [4], current trends and theoretical concerns support open wedge osteotomies with fixation [1].

Patellofemoral arthritis (PF-OA) frequently is associated with MC-OA. PF-OA frequently occurs in association with MC-OA and has consistently been a relative contraindication for HTO and an indication for total knee replacement [2]. The combination of the conditions limits patient selection and adversely influences long-term outcomes. Therefore, determining a concomitant procedure that can

W. S. A. Megied · M. A. Mahran (✉) · M. F. Thakeb ·
A. A. K. H. Abouelela
Department of Orthopaedics,
Ain-Shams University School of Medicine,
Cairo, Egypt
e-mail: mahmoudmahran@gmail.com

Y. Elbatrawy
Department of Orthopaedics, School of Medicine,
Al-Azhar University,
Cairo, Egypt

address the patellofemoral pathological condition has always been a challenge. Tibial tuberosity anteriorisation (TTA) has proven effective in reducing patellofemoral contact loads [12]; thus, combining TTA with HTO seemed a promising option. The combination includes two techniques. The CWHTO is combined with either anterior displacement of the distal fragment [3, 22] or a separate Maquet-like TTA osteotomy [3, 9, 10, 15, 18, 24]. We conducted a prospective study of our new technique—the dual osteotomy—which combines a Maquet-like TTA osteotomy with an OWHTO in cases of combined MC-OA and PF-OA. The dual osteotomy technique is not just a new combination of two osteotomies, but rather, it comprises every technical tip that has been reported and deemed imperative to improve long-term outcomes after HTO. To our knowledge, this is the first study in the English language literature that includes the open wedge technique in such a combination.

Patients and methods

Thirty-four knees in 30 patients underwent the dual osteotomy technique between May 2003 and June 2007. The study included ten knees in nine male patients and 24 knees in 21 female patients with a mean age of 45 years (age range 34–58 years). All patients were diagnosed with combined MC-OA and PF-OA with preoperative anatomical tibiofemoral angles (aTFA) exceeding 5° varus (normal aTFA is 7° valgus) (Fig. 1).

Pre-operative evaluation

Clinically, patients were assessed preoperatively and 24 months postoperatively using the Knee Society clinical rating system function score and knee pain score. Long standing films of both lower limbs were obtained to detect

any tibial extra-articular knee deformity by assessing the medial proximal tibial angle (MPTA) (normal range 87–90°) and measuring the aTFA. We excluded cases with proximal tibial varus deformity that predisposed to MC-OA (abnormal MPTA). Two other views were obtained for assessing the patellofemoral articulation—a lateral view of both knees in 30° of flexion to evaluate the extent of arthritis and a Merchant view to detect the existence of patellofemoral maltracking.

Inclusion criteria

Clinical and radiological parameters had to be met for inclusion in the study (Table 1).

Operative technique

Positioning

The patient is positioned supine on the operating table, with a bolster placed under the ipsilateral buttock to correct the external rotation that occurs with supine positioning. Image intensifier access to the whole limb, from the hip to the ankle, is checked. A high thigh tourniquet is applied. Before draping and for ease of checking limb alignment intra-operatively, the centre of the femoral head (femoral pulsation) and the ankle (just lateral to the tibialis anterior tendon) are marked with two metal markers. They are re-checked intra-operatively with the aid of the image intensifier.

Approach

A midline longitudinal skin incision is made starting 1 cm down the inferior pole of the patella and ending nearly 7 cm distal to the tibial tuberosity. The skin and subcutaneous tissue are retracted medially, and the medial periosteal ligamentous complex [periosteum, medial collateral ligament (MCL), and pes anserine tendons] is incised 1 cm medial to midline. It is important to leave a lateral cuff of tissue for later reattachment. Proximally, the incision crosses the confluence of deep fascia, the medial retinaculum, and the superficial MCL without violating the joint capsule. The whole medial periosteal ligamentous complex is sharply and subperiosteally dissected off bone. Dissection is continued posteromedially, allowing adequate exposure and removal of the offending medial osteophytes. The medial osteophyctomy allows complete subperiosteal release of the tethered MCL, neutralisation of the expected increase in medial joint pressure after opening the correction wedge, repositioning of the medially displaced medial meniscus, and symmetrical opening of the osteotomy gap.

Fig. 1 Preoperative anatomical tibiofemoral angles (aTFA) in degrees of varus

Table 1 Inclusion criteria

Clinical parameters	Radiological parameters
Age younger than 60 years	Evidence of medial and patellofemoral compartment affection
Active life style	aTFA $\geq 5^\circ$ varus
Clear complaint of anterior and medial knee pain	Spared lateral compartment
Flexion $\geq 90^\circ$	Normal MPTA
No fixed flexion deformity	No evidence of patellofemoral maltracking
Failure of conservative treatment	

aTFA anatomical tibiofemoral angle, MPTA medial proximal tibial angle

Dual osteotomy technique

The first procedure of the dual osteotomy technique is a tibial tuberosity anteriorisation osteotomy. After drilling is complete, the osteotomy is made under saline irrigation with a saw blade starting 1 cm medial to the tibial tubercle and extending distally for 10 cm. The osteotomy is continued from the medial side without dissecting through the lateral soft tissues to maintain fragment stability and accelerate healing.

The second osteotomy is then made. Under image intensifier view, two strictly parallel guidewires are introduced from the medial cortex, 5 cm distal to the joint line. The guidewires are then directed proximally towards the tip of the fibula in the anteroposterior view. In the medial cortex, bone is cut under saline irrigation with a saw blade that is made to slide along the two wires, stopping 10 mm before the proximal lateral cortex. Serial osteotome blades are introduced sequentially over each other in the osteotomy line to stop at the pre-described distance (Fig. 2). This serves to gradually open the

osteotomy gap, allowing stress relaxation of the far cortex to avoid iatrogenic fracture and consequent loss of stability intraoperatively.

Under image intensifier view, the mechanical axis is checked over the knee only, with a diathermy cable stretched between the metallic hip and ankle markers. With this method, there is no need to move the image intensifier to radiograph the hip or the ankle. Over-correction is attempted so that the mechanical axis passes approximately through the medial third of the lateral compartment (the Fujisawa point [16]). The osteotomy gap is held open by a wide lamina spreader and is measured in centimetres. The gap is held strictly rectangular (equal anterior and posterior gaps) until osteosynthesis is performed to preserve the native tibial slope.

Graft harvesting

Two blocks of corticocancellous bone are measured and harvested from the anterior iliac crest to fit the gaps of both osteotomies.

Osteosynthesis

An osteotome is used to slowly displace the tubercle 1–1.5 cm anteriorly, hinging on an intact distal cortex (Fig. 3) before fitting a corticocancellous bone block of the same size. The osteotomy is fixed with a 4-mm cancellous AO screw and a washer. We used an L or T proximal medial buttress AO tibial plate with two fully threaded AO 6.5-mm cancellous screws proximally and at least three 4.5-mm AO cortical screws distally. The plate is centred on the midsagittal or slightly posterior axis to prevent alteration of the natural tibial slope.

The medial periosteal ligamentous complex is repositioned over the plate and reattached with Ethibond sutures (Ethicon, Inc., Somerville, New Jersey). Haemostasis is achieved after tourniquet release, and the wound is closed in layers. A suction drain is routinely used to reduce compartmental pressures.

Fig. 2 Osteotome slides over wire under frequent image intensifier check

Fig. 3 Opening of tibial tubercle osteotomy with use of osteotome

Postoperative management

The reconstruction is stable enough to allow immediate passive range of knee motion provided the lateral cortex is left undisturbed. Active quadriceps strengthening exercises can begin when the patient's condition permits. No weight bearing is permitted on the operated side for six weeks. Patients then start partial weight bearing with crutches for another six weeks. At twelve weeks after surgery, full unguarded weight bearing is allowed.

Results

Union was achieved in all cases within 12 weeks (Fig. 4). The final evaluation was conducted at 24 months after surgery. The mean Knee Society clinical rating system function score increased from 61.3 (range 30–80) preoperatively to 87.3 (range 50–100) postoperatively, and the mean knee pain score increased from 27.3 preoperatively (range 10–30) to 47 (range 30–50) postoperatively (Table 2). Postoperatively, 70% of patients experienced no pain, 13% had mild or occasional pain, 10% experienced pain while climbing stairs, and 7% had pain during walking and while climbing stairs. aTFA from 0 to 10° valgus was achieved in approximately 91% of operated knees.

Complications

Intraoperatively, two cases experienced fractured lateral cortex and loss of correction. For those two cases, a plaster cast was applied to the extremity for six weeks before range-of-motion exercises were begun. Thus, the postoperative protocol was protracted and the decrease in knee range of motion compromised the function scores of these two cases at final follow-up.

Infection occurred in two patients. One was a superficial infection that subsided with regular dressing changes and administration of appropriate antibiotics according to culture and sensitivity. The other was a deep infection that recurred after two debridement procedures, necessitating early removal of the hardware. In that patient, the infection completely resolved and the osteotomy healed in a supplementary cast.

Discussion

HTO remains a valuable and durable solution for salvaging an arthritic knee with isolated medial compartment disease when performed using a good technique in a properly selected patient population [1]. Berman et al. [2] stated that "...by changing alignment and transferring weight-bearing stresses to stronger areas of the knee joint, the degenerative process can be slowed, arrested, or even reversed" long enough for patients to enjoy a demanding active life style without the limitations of total knee replacement. The indications and limitations of HTO are well discussed in the literature [1, 2, 7, 10]. PF-OA frequently occurs in association with MC-OA and has consistently been a relative contraindication for HTO and an indication for total knee replacement [2]. Maquet TTA osteotomy and its modifications evolved to treat patients with isolated patellofemoral pain from degenerative causes by decreasing the patellofemoral joint contact loads [12]. Thus, combining HTO with TTA as a treatment method targeting both compartments received considerable attention.

TTA combined with HTO has been reported to be used with two different techniques. The first is an isolated CWHTO that comprised anterior displacement of the distal tibial fragment (with its attached tibial tuberosity) [3, 22], and the second technique is a CWHTO combined with TTA as a separate osteotomy in the form of a Maquet or modified Maquet TTA osteotomy [3, 9, 10, 15, 18, 24]. The first technique was adopted by Saito et al. [22] who reported 96% pain relief of patellofemoral symptoms as assessed by a grinding test and improvement in Knee Society clinical rating system knee pain score from 50 to 94. In our opinion, this technique is a technically challenging procedure that could compromise the viability of the proximal fragment. We are in agreement with Bourguignon [3] who illustrated how pulling the shaft forward to advance the patellar ligament would markedly exaggerate the normal anatomical posterior overhang of the tibial epiphysis against the shaft. This offsets the lines of force, reduces the area of contact for healing, and stretches the popliteal structures. With the technique presented by Saito et al., the proximal tibia acquires coronal plane and

Fig. 4 Anteroposterior (a) and lateral (b) view radiographs show full union 12 weeks postoperatively

sagittal plane offsets that make any future total knee arthroplasty a complex surgery. Chang and Bennett [5] stated, “The safe amount of anterior displacement still must be determined”. This is especially true if a biomechanically sound anteriorisation distance is to be assured.

The second technique was adopted by other authors with variable results. Bourguignon [3] supported the combination, and Putnam et al. [18] reported morbidity equivalent to that resulting from HTO alone and excellent postoperative clinical results. For Hoffman et al. [9, 10] and Insall et al. [10], the combination fell out of favour because of the greater presumed operative stress and the high incidence of complications at that time. Nguyen et al. [15], in a comparative study of the combined procedure and isolated HTO, reported that adding TTA was useless, whereas Sasaki et al. [24] reported good results. Majima et al. [11] did not find the combination favourable at long-term follow-up despite reporting good results in the first five to six years postoperatively.

The CWHTO with removal of a bone wedge from a lateral approach and fixation with staples, a plate, or a

tension-band system was once popular [6]. Drawbacks of this technique are the risk of peroneal nerve injury, the need of fibular osteotomy or springing of the proximal tibiofibular joint, and the need for detachment of the extensor muscles. The wedge resection is not forgiving, and large corrections cause substantial shortening of the leg and an offset of the lateral proximal tibia. This can compromise future placement of the tibial component of a total knee replacement [13]. OWHTO has evolved to be the procedure of choice despite the lack of high-level evidence [4]. It can be “fine-tuned” intraoperatively and avoids most of the concerns associated with lateral closed wedge osteotomy [7]. To our knowledge, this is the first study in the English language literature that combines an OWHTO with a modified Maquet TTA a technique, a combination which we have named the *dual osteotomy*. The amount of TTA in the original Maquet osteotomy was 2–3 cm [12]. That amount was proven to be biomechanically unsound because of increases in the stresses on the superior pole of the patella [23] and reported skin problems [23]. In our series, we used a modified Maquet TTA, which limits anterior

Table 2 Knee society clinical rating system knee pain score

Pain	Score	Number of patients preoperatively	Number of patients postoperatively
None	50	0	21
Mild or occasional	45	0	4
Stairs only	40	0	3
Walking and stairs	30	24	2
Moderate occasional	20	4	0
Moderate continuous	10	2	0
Severe	0	0	0

advancement to only 1–1.5 cm, enough of a distance to reduce patellofemoral contact pressure of more than 40% [23].

The osteotomy combination used in the new dual osteotomy technique reverses the drawbacks of isolated HTO on patellofemoral kinematics. HTO, either as open or closed wedge, is associated with alteration in patellar height and thus alteration in patellofemoral contact pressures. Patella infera occurring after OWHTO causes anterior knee pain, patellar locking, crepitus, and limitation of knee motion. Eventually, the altered patellofemoral congruency and contact stress can lead to patellofemoral osteoarthritis [8, 25–27]. In disagreement with Wright et al. [28], we recommend the dual osteotomy as a routine HTO technique, especially in cases with mild patellofemoral degeneration.

The dual osteotomy technique is not just a new combination of two osteotomies, but rather, it comprises every technical tip that has been reported and deemed imperative to improve long-term outcomes after HTO. Maintaining the native tibial slope is important to avoid undue strain on both cruciate ligaments [20], which commonly are compromised by the degenerative process. To address this issue, we adopted every published recommendation to avoid alteration of the native tibial slope [21]. For example, the osteotomy planes were kept parallel. This was facilitated by complete subperiosteal release of the MCL to allow symmetrical opening of the osteotomy gap and was maintained by positioning the plate in the mid-sagittal plane or slightly posterior.

Many OWHTO techniques violate the MCL, at least partially [17]. We adhere to an MCL preservation policy. We use a longitudinal incision and subperiosteally elevate the MCL with the pes anserine tendons as far posteromedially as is required to expose the medial cortex and even to remove offending medial osteophytes. Thus, we eradicate an ongoing source of pain and permit repositioning of a tethered medial meniscus to resume its biomechanical function. The whole medial periosteal ligamentous sleeve is returned to its place thereafter to prevent the theoretical possibility of late valgus instability [17]. Maintaining an intact lateral cortex is imperative for the stability of fixation, and an aggressive rehabilitation program allows early range of motion from day one. The slow impaction of serial osteotomies sequentially over one another, under image intensification view, to the osteotomy gap with a waiting period between each one allows time for “elastic deformation” of the lateral cortex to accept the stresses of the opening wedge without breakage.

Our study was conducted with the use of standard implants, which was economically beneficial to a public health service in a developing country. We think that proper

patient selection and strict operative and postoperative protocols rendered our results satisfactory despite the lack of sophisticated instruments and implants. We used the function score and the knee pain score of the Knee Society clinical rating system. The knee pain score was preferred to the visual analogue score because it expresses grades of pain sensation as related to functional activities.

This study does have drawbacks consisting mainly in the short-term follow-up. An ongoing prospective study is underway to determine long-term outcomes. The study lacks comparison between isolated OWHTO and the dual osteotomy technique to determine the effect of the addition of TTA. A comparison of our results with results presented in the literature would not be directly meaningful because of the marked differences between our technique and other reported techniques.

Conclusion

The new dual osteotomy technique, which combines OWHTO with TTA, is effective in the short term in cases of combined MC-OA and PF-OA. We recommend its use, even in cases with isolated MC-OA.

Acknowledgement Special thanks to Dr. Hany El-Zahlawy for assistance with references and to senior editor and writer Dori Kelly, MA, for her usual outstanding job of manuscript editing and figure preparation.

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