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Case Report

Total knee arthroplasty following medial opening wedge tibial osteotomy Technical issues early clinical radiological results

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ABSTRACT

Medial opening wedge high tibial osteotomy is a popular treatment option for medial compartment osteoarthritis of the knee. One of the proposed advantages is easier conversion to a total knee replacement compared to lateral closing wedge osteotomies, although there are few studies to support this. We reviewed the technical considerations in 36 knees in which conversion of a medial opening wedge osteotomy to total knee arthroplasty was performed, and contrasted these to previously reported studies of knee arthroplasty after closing lateral wedge or dome osteotomies. The clinical results in 33 patients (34 knees) with minimum 2 year follow-up (mean 3.4 years, range 2 to 8 years) were compared to a control group of 1315 knee arthroplasties performed without prior tibial osteotomy. Total knee arthroplasty after a medial opening wedge osteotomy is relatively straightforward, although we encountered patella baja in 27% of cases, and an increased posterior tibial slope of over 15° in 21%. There was a lower Knee Society score and a lower pain score (more pain) in the study group compared to the control group. While technically straightforward in most cases, knee arthroplasty following medial opening wedge osteotomy in this study group yielded inferior clinical results compared to a group of knee arthroplasties performed without prior tibial osteotomy.

1. Introduction

Total knee arthroplasty after high tibial osteotomy has historically been reported to be more difficult than routine knee arthroplasty. Several studies have outlined technical concerns, including soft tissue problems, difficulty with patella eversion, managing retained hardware, managing coronal and sagittal plane deformities of the proximal tibia, and difficulties with ligament balancing [1–8]. Most of these studies, however, have reported these concerns following lateral closing or dome osteotomy. Furthermore, the literature is divided as to whether the results are as good as those obtained after a primary knee replacement performed without an osteotomy [3,4,6,9–12].

Medial opening wedge (MOW) tibial osteotomy has become increasingly popular, and now is the most commonly performed osteotomy at our institution [13]. Potential advantages of this technique include easier correction of coronal and sagittal plane deformities, preservation of bone stock and normal proximal tibial anatomy without disruption of the proximal tibiofibular joint, and avoidance of the peroneal nerve and muscles of the anterior compartment (thereby decreasing the likelihood of peroneal nerve palsy or compartment syndrome) [14]. Disadvantages of this technique include the risk of delayed or non-union, loss of correction, hardware failure, intra-operative fracture of the lateral tibial plateau, and violation of the superficial medial collateral ligament [14–17].

In contrast to the literature on conversion of lateral closing wedge osteotomies, there is little information regarding the technical issues involved in converting a medial opening wedge osteotomy to a total knee replacement, and the results of conversion. The purpose of this study was first to review our experience in performing a total knee replacement after medial opening wedge osteotomy with regard to the technical issues involved, with the hypothesis being that this is an easier conversion to knee arthroplasty than after other types of tibial osteotomy. Secondly, we sought to compare the early clinical results in our cohort to a group of primary knee replacements who had not previously had a tibial osteotomy, to determine if the clinical results are equivalent.

2. Methods

Patients who had undergone total knee arthroplasty after medial opening wedge osteotomy were identified from the arthroplasty database held at our institution and by reference to patient charts. Between 1998 and 2007, 36 knees in 35 patients underwent total knee arthroplasty after a medial opening wedge osteotomy. Technical issues relating to the surgery were reviewed for all 36 cases. One patient died from causes unrelated to the surgery, and one patient was lost to follow-up at 1 year, leaving 34 knees (33 patients) with minimum 2 year follow-up available. The mean follow-up time for the clinical group was 3.4 years (range 2 to 8 years).

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Information regarding the technical issues involved in the surgery was obtained from chart review, and review of the pre-arthroplasty radiographs. Medical records were reviewed to ascertain when the high tibial osteotomy had been performed, whether there had been complications related to the osteotomy, operative details, and immediate postoperative complications. This information was used in addition to the prospectively collected operative data held in our database. Preoperative radiographs taken included a 3 ft standing hip–knee–ankle film in addition to lateral and skyline views of the knee. Pre-arthroplasty (post-osteotomy) radiographs were reviewed for mechanical alignment of the limb, whether the osteotomy had united, posterior slope of the tibia, translation of the midpoint of the tibial plateau in relation to the tibial shaft axis [18], and patella height. The patella height was measured with the Insall-Salvati and Blackburne-Peele methods.

Clinical results were reviewed for the 33 patients (34 knees) at minimum two-year follow-up. Knee Society scores [19] were collected preoperatively, at 3 months postoperatively, and annually thereafter. Knee Society knee scores under 80 were considered to have a fair/poor result [20]. Postoperative films were taken at the 6 week and 1 year mark, and annually thereafter, and included an antero-posterior weight bearing view of the knees, in addition to lateral and skyline views of the knee. Postoperative radiographic parameters measured included the alignment of the femoral and tibial components on the antero-posterior film, the femoral flexion angle and slope of the tibial component on a lateral film, the anatomic femoro-tibial angle, measurements of the patella height by the Insall-Salvati and Blackburne-Peele ratios, and radiolucencies around the femoral and tibial components.

The Knee Society scores for the study group were compared to a group of 1315 patients selected from our arthroplasty database. This control group had primary knee arthroplasties for osteoarthritis performed during the same time period (1998 until 2007) by the same surgeons with posterior stabilized components and patella resurfacing, and had not had any osteotomy procedure performed prior. There was no difference between the study and control group with respect to BMI or length of follow-up. The control group were significantly older (mean age study group 57 years, mean age control group 69 years $p<0.001$), and had a higher proportion of females compared to the study group (control group male/female ratio 509/806, study group 21/13, $p<0.01$).

For the entire cohort of 35 patients, the average age of the patients was 57 years (range, 34 to 73 years), and the average body mass index was 32.6 (range 20.3 to 50.8). The average time from the osteotomy to the arthroplasty procedure was 4.7 years (range 1.4 to 9.9 years). In all but one case the osteotomy had been performed initially with a Puddu plate (Arthrex Inc, Naples, Fla), and in the remaining instance with a T-plate. Six knees had revision osteotomy procedures done, and in five of these cases it was performed for delayed or non-union of the osteotomy. In these cases the osteotomy site was bone grafted and underwent repeat internal fixation. The remaining revision osteotomy was performed for excessive posterior slope, and involved conversion to an anterior closing wedge osteotomy. All osteotomies had united at the time of conversion to arthroplasty.

Twenty four of the knees had at least one additional procedure to the knee either prior to or after the index osteotomy procedure, and five knees had at least four additional procedures. These procedures included hardware removals (11), revision high tibial osteotomy (6), open meniscectomy (4), anterior cruciate reconstruction (3), patella realignment then subsequent patellectomy (1), intramedullary nailing of the femur and tibia for open fracture (1), lateral release (1), and arthroscopy (nine documented at our institution). Except for hardware removals, revision high tibial osteotomies and two arthroscopies, all other procedures were performed prior to the index osteotomy procedure.

Statistical analysis was made using SPPS for Windows V18 (SPSS Inc, Chicago, Ill). A chi square test was used for comparing proportions between groups, and the Student *t*-test for comparison of means between groups. Linear regression models were used to examine which factors correlated to the Knee Society knee and function score, and the pain score component of the Knee Society knee score. Factors entered into the models were age, gender, BMI, length of follow-up, and whether the patient had a medial opening wedge osteotomy prior to the knee replacement.

3. Results

3.1. Part A: Technical issues

Preoperative radiographs had been lost by the hospital in two cases, leaving 34 knees with pre-arthroplasty (post-osteotomy) radiographs for review.

The mean mechanical axis of the limb preoperatively was 2.2° varus (range 12° varus to 8.5° valgus). A frequency distribution of the mechanical axis of the limb is shown in Fig. 1. Posterior tibial slope was on average 10.6° (range 1.8° to 29.4°). The frequency distribution of posterior slope of the tibia is shown in Fig. 2. Seven knees had over 15° posterior slope (Fig. 3). Mean translation of the midpoint of the tibial plateau in relation to the tibial shaft was 2.5% (range 0.2 to 25.2%). In no case did the degree of translation on the preoperative radiograph lead to impingement of the keel of the prosthesis on the postoperative radiograph.

The mean preoperative Insall-Salvati ratio was 0.91 (range 0.64 to 1.33). In 9 knees (27%), the ratio was less than 0.8 and the patella considered infera. In one case the ratio was above 1.2. The mean preoperative Blackburne-Peele ratio was 0.70 (range 0.35 to 1.3). In five knees (15%) the ratio was less than 0.54, and in one knee it was above 1.06.

The previous anteromedial skin incision was incorporated into the incision for the knee replacement in 30 cases, and in six cases a separate incision was made (Fig. 4). There were no major wound complications in this series.

All cases were performed through a medial parapatellar approach. Difficulty with patella eversion was noted from the operation record in five cases, necessitating a prophylactic pin in the patella tendon in three cases. An extensile exposure (rectus snip) was required in only one case. Those cases in which patella eversion was difficult had a lower Insall-Salvati and Blackburne-Peele ratios (difficult patella eversion: mean Insall-Salvati ratio 0.74 and mean Blackburne-Peele ratio 0.52; no difficulty with patella eversion: mean Insall-Salvati ratio 0.93 and mean Blackburne-Peele ratio 0.74; $p=0.008$ and $p=0.01$ respectively).

Previous metalwork was removed at the time of surgery in 23 cases, and in 11 cases it had been removed previously. In one case the plate and distal screws were left in situ, and in another the plate was left in situ although all screws were removed. In six knees broken screws were noted on the preoperative radiograph, but in no case did they prove to be problematic.

Soft tissue balancing was accomplished without additional ligament releases beyond that required for exposure in 27 cases. In three knees a more extensive medial release was undertaken to address medial tightness, consisting of release of the deep medial ligament beyond the midcoronal plane, and semimembranosis. In six knees, some form of lateral structure was released for balance, which consisted of popliteus only in four cases, the lateral collateral in one case, and the posterolateral corner of the tibia in one case. All cases in which a lateral structure was released had metalwork removal at the time of arthroplasty.

Only one lateral retinacular release was performed intra-operatively to correct lateral patella subluxation (2.8%).

A tibial stem was used in 10 cases, and only in those who had metalwork removed at the time of the arthroplasty. Most stems were short (equal to or less than 100 mm), and no offset stems were needed. The reason for use of a tibial stem was generally to bypass a potential stress riser from the metalwork removal. Hence, in almost half of the cases where metalwork was removed at the time of surgery, a stem was used. Nine of

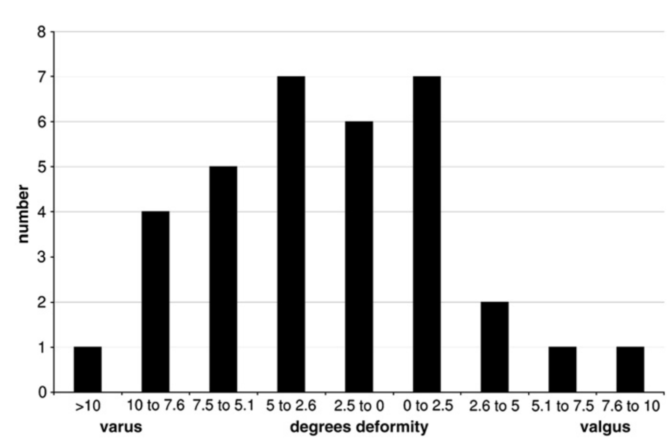

Fig. 1. Frequency distribution of preoperative mechanical alignment of limb.

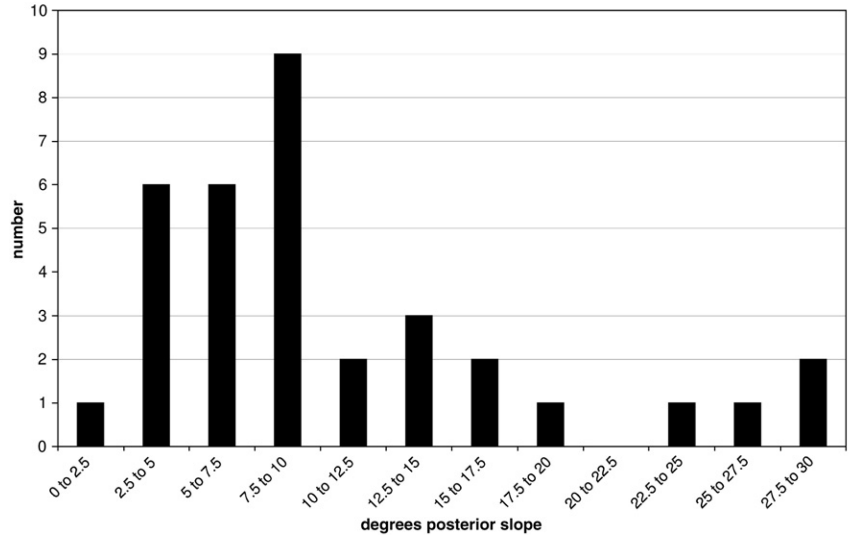

Fig. 2. Frequency distribution of preoperative posterior tibial slope.

the 10 stems used where early in the series (prior to 2004), indicating that as experience with conversions of medial opening wedge osteotomies has developed, there is less tendency to use a stem on the tibial component.

In 35 knees the posterior cruciate ligament was sacrificed and posterior substituting components used, and in one knee a posterior cruciate retaining implant was used. No augments or wedges were used in this series. In one case autologous bone graft was applied to the area of the previous plate spacer.

3.2. Part B: Clinical results

The mean preoperative Knee Society knee and function scores were 40.6 (range 15 to 66) and 50.2 (range 30 to 80). The mean postoperative Knee Society knee and function scores were 87.8 (range 57 to 100) and 73.2 (range 15 to 100). The mean change in knee and function scores were 47.0 (range 14 to 83) and 22.6 (range −30 to 55) respectively. Of the seven patients (eight knees) in the study group with a poor result (considered as Knee Society Score under 80), two patients were workers compensation cases and one patient (two knees) was a chronic pain patient prior to undergoing the total knee replacement. There was one workers compensation case and one chronic pain patient with Knee Society scores over 80 in the study group. One patient with a score less than 80 had a revision osteotomy procedure done prior to knee replacement, although there were also five patients with a score above 80 who had revision osteotomy procedures done. There was no clearly discernable reason for the poor results in the remaining three patients.

Postoperative Knee Society knee and function scores, the pain component of the Knee Society knee score, and the maximum flexion achieved for the study and control groups are presented in Table 1. The study group had a lower pain score (more pain) and a lower Knee Society knee score compared to the control group. In a linear regression model with the outcome being the pain score, a previous medial opening wedge osteotomy and female gender were significant factors correlating to a lower pain score. Similarly, in a linear regression model with the outcome being the Knee Society knee score, a previous medial opening wedge osteotomy and female gender were significant factors correlating to a lower Knee Society knee score.

Given that the workers compensation cases and chronic pain patients may skew results downwards in the smaller study group, the analysis was repeated with these six

Fig. 3. Lateral radiograph of knee post medial opening wedge osteotomy, with increased posterior slope.

Fig. 4. Example of skin incision for total knee arthroplasty incorporating the previous medial opening wedge osteotomy incision.

Table 1
Knee Society scores for study and control groups.

Knee Society component scores	Study group $n=34$	Control group $n=1315$	P value
Pain	40.4	46.2	<0.001
Flexion	117	115	0.569
Function score	73.2	70.3	0.503
Knee Score	87.8	93.3	0.001

cases excluded from the study group (Table 2). The study group still had a significantly lower pain score, and in the same linear regression analysis as above, a previous medial opening wedge osteotomy and female gender remained significant factors correlating with a lower pain score (more pain). However, whilst the Knee Society knee score remained lower in the study group, in the same linear regression model as before, only female gender was a significant factor in correlating with a lower Knee Society knee score.

Several postoperative complications occurred in the study group. Five patients required a manipulation under anaesthetic, one patient required a debridement for patella clunk, and one patient required drainage of a subcutaneous hematoma. Radiographic analysis showed well aligned components in the study group (Table 3). None of the radiolucencies seen around the tibial or femoral component were progressive or complete.

4. Discussion

The present study has demonstrated that while knee arthroplasty performed after a medial opening wedge osteotomy is technically straightforward in most instances, the clinical results were inferior to a control group of knee arthroplasties performed without prior osteotomy. There was a lower Knee Society knee score and more pain in the study group compared to the control group. Despite increasing use and good clinical reports of medial opening wedge tibial osteotomy for medial compartment osteoarthritis, there is little information about the difficulties of converting this osteotomy to a total knee arthroplasty or on the results. The only other study that we are aware of reported on nine knees which had been converted to a total knee arthroplasty after medial opening wedge osteotomy performed with an external fixator, and noted that one of nine patients had patella baja and that they encountered no technical difficulties [21].

Compared to historical controls of knee arthroplasty performed after either closing lateral wedge or dome proximal tibial osteotomy, our results suggest that total knee arthroplasty after medial opening wedge osteotomy may allow for easier exposure and less lateral retinacular releases (Table 4). One of the main theoretical advantages is preservation of relatively normal proximal tibial anatomy: however, this is impossible to quantify with the present study methodology.

Several technical issues need to be considered in conversion of a medial opening wedge osteotomy to a total knee replacement. The problem of preoperative patella baja was still encountered in the present study, and was related to difficulty with patella eversion. A number of authors have reported on measurement of patella height after medial opening wedge tibial osteotomy, with most noting a reduction in the Blackburne-Peele [22–25] or related indices [26] post

Table 2
Knee Society scores for study and control groups, excluding workers compensation cases and chronic pain patients from study group.

Knee Society component scores	Study group $n=28$	Control group $n=1315$	P value
Pain	42.9	46.2	0.026
Flexion	118	116	0.489
Function score	75.9	70.3	0.244
Knee Score	90.5	93.3	0.127

Table 3
Postoperative radiographic parameters in study group.

	Mean	Range
Anatomical femoral–tibial angle (degrees)	5.7	2 to 10
Femoral valgus angle (degrees)	6.4	4 to 9
Femoral flexion angle (degrees)	6.9	0 to 18
Tibial AP angle (degrees varus)	0.5	4 varus to 2 valgus
Tibial posterior slope (degrees)	4.7	0 to 12
Insall-Salvati ratio	0.92	0.5 to 1.2
Blackburne-Peele ratio	0.66	0.2 to 1
Radiolucencies tibial component	10/34	
Radiolucencies femoral component	3/34	

opening wedge osteotomy. The effect on the Insall-Salvati ratio is more variable with some noting a decrease [22,25], and others noting no difference [27]. The extra medial dissection to remove osteotomy hardware at the time of conversion to knee arthroplasty can lead to medial laxity requiring lateral ligament release to balance the knee, given that all cases in which a lateral structure release was performed occurred in cases in which the osteotomy hardware was removed at the time of arthroplasty. Extensive lateral structure releases as has been described by some authors after a closing lateral wedge osteotomy [1,6] did not need to be performed. We tended to use tibial stems when metalwork was removed at the time of surgery to bypass potential stress risers, although as experience has developed with these conversions stems were used less often. While tibial deformity as measured on the antero-posterior preoperative radiograph seemed minimal, 21% of our medial opening wedge group had a tibial slope of over 15°. Tibial slope tends to be increased after a medial opening wedge osteotomy, which could lead to large anterior tibial resections and/or defects in the posterior tibia, or affect flexion/extension balancing.

Previous studies are divided as to whether a total knee replacement performed after a lateral closing wedge tibial osteotomy has equivalent results to that of a standard primary knee replacement. Some authors advocate that there is no difference between the two groups [5,9–11], whereas others have reported inferior clinical results in those with a previous tibial osteotomy [4,6,12,28].

We found a lower knee score and more pain in our study group of knee arthroplasties performed after a medial opening wedge osteotomy compared to a control group of primary knee arthroplasties performed by the same surgeons during the study period. While the control and study groups were not equivalent in terms of age and gender distribution, controlling for these factors still revealed a lower knee score and more pain in the study group. Even in the best case scenario excluding patients who would predictably fare poorly (workers compensation cases and chronic pain patients) from the study group, the study group still had significantly more pain than the control group.

Given the inferior clinical results and increased technical complexity in converting a medial opening wedge osteotomy to a total knee replacement compared to a primary knee replacement, one may question whether undertaking an opening wedge osteotomy in the first instance is worthwhile. This paper is not intended to answer this question, but we offer the following observations. We conservatively estimate 300 to 350 opening wedge osteotomies were performed during the study period by our sports medicine colleagues at our institution. Given that we have revised 36 of these to knee arthroplasty, we estimate an approximate revision rate of 10%. We have not seen an increase in recent years of the numbers of medial opening wedge osteotomies coming to knee arthroplasty. This rough guide to the survivorship of the medial opening wedge osteotomy is in keeping with published results of this procedure [27,29–31]. It would appear that the majority of patients having a medial opening wedge tibial osteotomy are satisfied with the procedure, and a relatively small percentage come to

Table 4
Technical issues and clinical outcomes for previous reported series of TKA after high tibial osteotomy.

	n	Mean follow-up (years)	Patella baja (%)	Difficult patella eversion (%)	Extensile approach	Lateral release (%)	Lateral ligament or other structure release (%)	Bone graft or augments	Other technical problems	Clinical scores:HTO group versus control	Flexion postop:HTO group versus control	Revision or failure rates
Windsor [1]	45		80	51	4.4% quads turndown	46.7	22.2		Impingement keel of prosthesis			
Meding [7]	95	8.6	18.9		0%	45	10.5					One case only revised
Amendola [9]	42	3.1				14.2				No difference	Lower in HTO group	
Nizard [4]	63	4.6			11% tubercle osteotomy	23.8		11.1% bone graft	Problems due to deformity tibia 40%	Lower in HTO group	No difference	No revision in HTO or control group
Haddad [5]	50	6.2	56		16% rectus snip	44			32% impingement keel of prosthesis	No difference	Lower (trend)	No difference in revision or re-operation rate
Katz [6]	21	2.9		6	2% tubercle osteotomy	10	10			Lower in HTO group		Higher revision rate in HTO group
Gill [8]	30	3.8			23% quads turndown	37		10% bone graft				
Haslam [12]	51	12.6								Lower in HTO group	Lower in HTO group	Higher revision rate and re-operation rate in HTO group
Bergenudd [10]	14	6								No difference	No difference	
Meding [11]	39	7.5								No difference	No difference	
Parvizi [28]	34	15.1				26.4						High rate revision & radiographic loosening for entire cohort of 166
Karabastos [3]	20	5		27		31.8		9% wedge		Trend towards inferior results in HTO group		
Kaper [32]	46	3.9		54.5								
Current study	36	3.4	27	13.9	2.8% rectus snip	2.8	16.7	2.8% bone graft		Inferior results in HTO group	No difference	No revisions

conversion to knee arthroplasty because of ongoing pain from under correction, loss of correction of the deformity, or for other reasons. The technique for opening wedge osteotomy has continued to evolve with locking plate technology which may lead to less loss of correction.

We conclude that converting a medial opening wedge proximal tibial osteotomy to a total knee arthroplasty is relatively straightforward technically, but the clinical results at early follow-up are inferior to that of arthroplasties performed on knees that have not had a prior tibial osteotomy.

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