Total knee arthroplasty after high tibial osteotomy: a comparison of opening and closing wedge osteotomy

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Abstract

Purpose High tibial osteotomy (HTO) is frequently used to treat varus osteoarthritis in younger patients with the goal of delaying the need for total knee arthroplasty (TKA). While it has been reported that the results of TKA following HTO are worse than those in patients without prior knee surgery, the influence of osteotomy technique (medial opening-wedge versus lateral closing-wedge) has not been explored. The purpose of this study was to evaluate the influence of HTO technique on the performance and results of TKA. **Methods** A total of 141 TKA's performed in 118 patients with prior HTO (24 opening wedge and 117 closing wedge) were reviewed at a mean follow-up of two years. Reviewed data included intra-operative factors (tourniquet time, the need for additional exposure, and intra-operative complications),

clinical results (International Knee Score (IKS)) and radiographic assessment of limb alignment.

Results The average IKS knee and function scores improved from 54.0 and 60.3 to 87.0 and 79.5 ($p < 0.0001$). There was no significant difference in IKS scores based on osteotomy technique. There was a trend toward an increased need for tibial tubercle osteotomy in the closing wedge group. There was an increased need for extensive medial release in the opening wedge group and extensive lateral release in the closing wedge group. No differences in tourniquet time, complication rates, or hip-knee-ankle angle were noted between the two groups.

Conclusions Radiographic limb alignment, patient-reported outcomes, and complication rates are equal in patients undergoing TKA after opening and closing wedge HTO.

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Introduction

High tibial osteotomy (HTO) is an accepted and reliable option for the treatment of varus osteoarthritis in young, active adults. High tibial osteotomy typically results in pain relief and improved knee function in 80–90 % of patients [3, 10, 21]; however, osteoarthritis progression often leads to deterioration of results with the passage of time [13, 14, 18, 22, 24]. When symptomatic progression occurs, total knee arthroplasty (TKA) is frequently performed. In a ten year follow-up study reported by Insall et al., TKA was necessary in 23 % of patients previously treated with HTO [9]. The presence of a prior HTO complicates the performance of TKA. Significant preoperative planning is required and intra-operative difficulties can be encountered.

Several studies have reported poorer functional and clinical results of TKA in patients with prior HTO relative to patients without prior knee surgery; however, relatively little is known about the influence of osteotomy technique on this

relationship [4, 16, 17]. The two most commonly performed HTO techniques for varus osteoarthritis are medial opening wedge HTO and lateral closing wedge HTO. Closing wedge HTO has a long history of use in cases of varus osteoarthritis and the majority of studies of results of TKA after HTO focus on lateral closing wedge osteotomies [2, 20]. Frequently reported problems are related to previous surgery and consist of hardware removal, joint exposure, dealing with tibial deformities due to the previous osteotomy and managing soft tissue mismatches. Opening wedge osteotomy has gained popularity in recent years, because there is no need for fibular osteotomy and the perception that the resulting corrections are more precise. Significantly less data is available regarding TKA after opening wedge high tibial osteotomy, but several authors have reported some disadvantages, such as donor site morbidity and lower osteocyte viability (longer heal) and viral disease transmission. In association with these concerns, weight bearing is usually allowed later than closing wedge osteotomies. In cases of deformities, greater than 10–15° lateral hinge rupture and loss of correction can occur [23]. Other disadvantages are slight tibial lengthening and low patella. This last aspect is relatively common, as demonstrated by biomechanical and clinical studies [5–7].

We postulate that radiographic limb alignment, patient-reported outcomes, and complication rates are equal in patients undergoing TKA after opening and closing wedge HTO.

Materials and methods

Patients

The prospectively collected TKA registry at our institution was asked to identify TKAs that were performed after high tibial osteotomy. Between January 1, 1996, and January 31, 2012, a total of 2,849 TKAs were performed at our institution. Of these cases, 141 arthroplasties in 118 patients were performed in patients who had undergone prior HTO for varus osteoarthritis (24 medial opening wedge and 117 lateral closing wedge). These 141 cases form the study group. Each arthroplasty was performed with the Tornier total knee arthroplasty system. (Tornier, St. Ismier, France).

Data collection

For each procedure, prospectively collected data from the TKA registry was obtained retrospectively. Data collection included: International Knee Society (IKS) Score pre-TKA and at final follow-up [8]; the Hip-Knee-Ankle (HKA) angle pre-TKA and post-TKA; whether a tibial tuberosity osteotomy (TTO) was performed; details of any lateral or medial

release performed; the thickness of the tibial cut (laterally for medial compartment arthrosis and medially for lateral compartment arthrosis); the degrees of valgus in which the femur was cut; any complications during the TKA; any post-operative complications; and the tourniquet time. The HKA angle was obtained from full-length weight-bearing radiographs in all cases.

Statistics

Sample means, standard deviations, and ranges were calculated for continuous variables. Because the data were normally distributed, *t*-tests were used to compare sample means of continuous variables between the two osteotomy groups. Fisher's exact test was used to compare nominal and categorical variables. A power analysis was performed based on previously reported values of IKS scores following TKA. It was determined that the available sample size was sufficient to detect a ten point difference in IKS scores between the two groups with $\alpha=0.05$ and a power of 0.84.

Results

Pre-TKA measurements

Twenty-four knees (17 %) had undergone prior medial opening wedge HTO and 117 (83 %) had undergone prior lateral closing wedge osteotomy. Fifty-seven (48.3 %) patients were female and 61 (51.4 %) were male. The mean age at the time of the osteotomies was 55.0 ± 9.4 years (range: 22 to 69 years) and the mean time from HTO to TKA was 12.2 ± 6.3 years (range: 1.5 to 34.4 years). Mean patient age at the time of TKA was 67.2 years. The mean pre-TKA IKS knee and function scores were 54.0 ± 16.5 and 60.3 ± 18.3 , respectively. The mean pre-TKA HKA angle was $179.5 \pm 6.2^\circ$ (range: 162 to 197°). At the time of TKA, 68 (48.2 %) knees had valgus alignment and 73 (51.8 %) had varus alignment. No significant differences between the medial opening wedge group and lateral closed wedge group were noted among pre-TKA measurements, except for time from HTO to TKA, which was significantly longer in the closing wedge HTO group (Table 1).

Intra-operative findings (during TKA)

The overall mean tourniquet time of was 84.3 ± 20.0 min (range: 50 to 140 min) with no difference between the two groups. A tibial tubercle osteotomy was performed in 28 cases (19.8 %) and a quadriceps snip was performed in three cases (2.1 %) for joint exposure. There was a trend toward increased need for additional exposure manoeuvres in the closing wedge group (Table 2).

Table 1 Pre-total knee arthroplasty (TKA) comparison of the opening and closing wedge groups

	Opening (n=24)	Closing (n=117)	Significance
Age at the time if HTO (years)	57.3±7.0	54.5±9.7	<i>p</i> =0.18
Time from HTO to TKA (years)	7.4±4.7	13.2±6.2	<i>p</i> <0.0001
Age at the time of TKA (years)	64.3±7.6	67.8±9.8	<i>p</i> =0.10
Sex (percent male)	16/24 (66.7 %)	60/117 (51.3 %)	<i>p</i> =0.18
Weight (kilograms)	80.0±15.1	82.3±16.9	
BMI (kg/m ²)	27.8±5.1	29.4±5.2	
Patella Height (Blackburn-Peele Index)	0.79±0.22	0.79±0.32	<i>p</i> =1.0
IKS Knee Score	56.3±13.6	53.6 ±16.8	<i>p</i> =0.40
IKS Function Score	59.4±15.1	60.5 ±18.6	<i>p</i> =0.78
Mean Hip-Knee-Ankle angle (degrees)	178.5±6.1	179.7±6.3	<i>p</i> =0.41
Limb alignment			<i>p</i> =0.41
Varus	14 (58.3 %)	59 (50.4 %)	
Valgus	10 (41.7 %)	58 (49.6 %)	
Extension Deficit (degrees)	2.1±4.8	3.1±5.3	<i>p</i> =0.39
Flexion (degrees)	119.8±14.0	112.7±16.5	<i>p</i> =0.06

BMI body mass index, HTO high tibial osteotomy, IKS International Knee Society

Overall, medial release was performed in 87 knees (61.7 %). The release consisted of the capsule along in 61 cases (43.3 %), the capsule and semimembranosus tendon in six cases (4.2 %), and the capsule, semimembranosus tendon and medial collateral ligament MCL) in 20 cases (14.2 %). Significantly more medial releases were required in the opening wedge group, as well as more significant releases (involving more than just capsule) (Table 2).

A lateral release was performed in 78 knees overall (55.3 %). The release consisted of the capsule in 38 cases (26.9 %), the capsule and IT band in 26 cases (18.4 %),

fenestration of the lateral collateral ligament (LCL) in six cases (4.2 %), and fenestration of the popliteus tendon in six cases (4.2 %). A lateral epicondyle osteotomy was performed in two cases (1.4 %). While there was no significant difference in the need for a lateral release between the two groups, significant release (involving more than capsule alone) was much more frequent in the closing wedge group (Table 2).

There were intra-operative complications in four cases (2.8 %). Complications included one medial epicondyle fracture in the opening wedge group. In the closing wedge

Table 2 Intra-operative comparison of the opening and closing wedge groups

	Opening (n=24)	Closing (n=117)	Significance
Tourniquet Time (minutes)	86.2±20.4	84.0±20.0	<i>p</i> =0.63
Additional Exposure Performed	2 (8.3 %)	29 (24.8 %)	<i>p</i> =0.08
Tibial tubercle osteotomy	2 (8.3 %)	26 (22.2 %)	
Quadriceps Snip	0 (0 %)	3 (2.6 %)	
Femoral Valgus Cut (degrees)	6.6±0.9	6.3±1.0	<i>p</i> =0.17
Thickness of Tibial Cut (mm)	8.7±1.3	6.9±1.5	<i>p</i> =0.0001
Medial Release Performed	22 (91.7 %)	65 (55.5 %)	<i>p</i> <0.0001
Capsule only	13 (54.2 %)	48 (41 %)	
Capsule + semimembranosus	0 (0 %)	6 (5.1 %)	
Capsule + semimembranosus + MCL	9 (37.5 %)	11 (9.4 %)	
Lateral Release Performed	11 (46.0 %)	67 (57.2 %)	<i>p</i> =0.32
Capsule only	10 (41.7 %)	28 (23.9 %)	
Capsule + IT band	1 (4.2 %)	25 (21.0 %)	
Lateral Collateral Ligament	0 (0 %)	6 (5.1 %)	
Popliteus	0 (0 %)	6 (5.1 %)	
Lateral Epicondyle Osteotomy	0 (0 %)	2 (1.7 %)	
Intra-operative complications	1 (4.2 %)	3 (2.6 %)	<i>p</i> =0.33

IT Iliotibial, MCL medial collateral ligament

group, two tibial fractures and one LCL laceration occurred. There were no significant differences in complication rates between the two groups.

Outcomes

Postoperatively, the overall mean HKA angle was $180.3 \pm 3.3^\circ$ (range: 173 to 191°), with no difference noted between the two groups (Table 3). The mean IKS knee and function scores at final follow-up of two years improved to 87.0 ± 15.2 and 79.5 ± 20.9 respectively, both significantly improved from pre-TKA ($p < 0.0001$). Post-operative complications occurred in 14 cases (9.9 %). Rates were similar between the two groups (Table 3). In the opening wedge group, there were two cases of post-operative stiffness. In the closing wedge group, there was one case of stiffness, one periprosthetic fracture, one peroneal nerve neuropraxia, four cases of persistent post-operative pain, two cases with instability, one superficial wound infection, and two deep infections. Post-TKA range of motion and patellar height were no different between the two groups (Table 3.)

Discussion

The most significant finding of our study is that osteotomy technique (medial opening wedge versus lateral closing wedge) does not significantly impact IKS scores at a mean of two years following TKA performed after an HTO. We noted that more medial releases needed to be performed following a medial opening wedge TKA, while more significant lateral releases needed to be performed following a lateral closing wedge TKA. While there was a trend toward a great need for tibial tubercle osteotomy or quadriceps snip for exposure in the lateral closing wedge group, there was no increase in operative time or complications in this group.

Previous work describing the outcomes of TKA following HTO is has demonstrated poorer outcome in those who have undergone prior osteotomy [11, 15, 24]. Intra-operative complications have been noted to be increased in

this population. However, we are aware of no prior work comparing outcomes of TKA following medial opening HTO with outcomes following lateral opening wedge HTO.

The increased need for medial release in the medial opening wedge group that we noted in our study is not surprising. The medial structures are tensioned during the medial opening wedge HTO and are also subject to scarring following surgery, both of which contribute to the need for later release. In our series, 58.3 % of patients in the opening-wedge group had a pre-operative varus deformity in the opening wedge osteotomy group, potentially contributing to the higher incidence of medial release in that group. Similarly, the higher rates of lateral release following a lateral closing wedge HTO are most likely due to post-operative scarring that occurs on the lateral side of the knee following osteotomy.

While lateral closing wedge osteotomy theoretically distalises the joint line and increases patellar height [6, 7], clinical evidence indicates patella infera is actually more common following this procedure [1, 12, 19]. This finding may be a consequence of post-operative immobilisation and subsequent scarring of the patellar tendon in this population. Opening wedge high tibial osteotomy also predisposes to patella infera, as demonstrated in several clinical studies [5, 7, 19]. These earlier findings were confirmed in our study. Both groups demonstrated lower overall patellar height post-TKA relative to pre-TKA. While no significant differences were noted between the groups, there was a trend toward lower patellar height in the closing-wedge osteotomy group post-operatively (Table 3).

There are significant limitations of this study. First, in comparing opening to closing wedge HTO's, we are not comparing randomised groups of patients, but rather patients that underwent one procedure or the other for a variety of undefined reasons. Table 1 demonstrates the groups to be relatively similar in many respects, but it is possible that other unquantified differences between the groups do exist, potentially biasing our results. Further, because the HTO's were performed at a variety of centres for a variety of indications, we lack details about these

Table 3 Post-TKA comparison of the opening and closing wedge groups

	Opening (n=24)	Closing (n=117)	Significance
Mean follow-up time (years)	1.2 $\pm$ 1.1	2.4 $\pm$ 2.7	$p < 0.001$
IKS knee score	84.8 $\pm$ 13.8	87.5 $\pm$ 14.1	$p = 0.42$
IKS function score	81.7 $\pm$ 16.2	79.0 $\pm$ 21.2	$p = 0.68$
Hip-knee-ankle angle (degrees)	179.9 $\pm$ 2.5	180.4 $\pm$ 3.5	$p = 0.91$
Patella height (Blackburn-Peele index)	0.70 $\pm$ 0.16	0.60 $\pm$ 0.25	$p = 0.07$
Extension Deficit (degrees)	0.5 $\pm$ 3.0	0.3 $\pm$ 3.6	$p = 0.80$
Flexion (degrees)	111.7 $\pm$ 21.2	114.8 $\pm$ 13.0	$p = 0.35$
Post-operative complications	2 (8.4 %)	12 (10.3 %)	$p = 1.0$

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procedures that again could reflect differences in our two patient groups for which we have not controlled. Finally, due to the evolution of HTO surgical technique over time, the time from HTO to TKA in the lateral closing wedge groups is considerably longer than the medial opening-wedge group. The medial opening-wedge group thus represents earlier progression to TKA than the lateral closing wedge group. This difference could reflect intrinsic differences in these patient populations that may influence their outcome after TKA. Only an evaluation of TKA outcomes in patients who were initially randomised to one type of osteotomy or the other can effectively allow for these differences.

Conclusion

Radiographic limb alignment, patient-reported outcomes, and complication rates are equal in patients undergoing TKA after opening and closing wedge HTO.

Conflicts of interest One of the authors receives royalties from Tornier. Three authors have received research and travel support from Tornier.

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