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# Total knee arthroplasty after opening– versus closing-wedge high tibial osteotomy. A 135-case series with minimum 5-year follow-up

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## A B S T R A C T

### Keywords:

Total knee arthroplasty  
Closing-wedge high tibial osteotomy  
Opening-wedge high tibial osteotomy  
Outcome  
Complications

**Introduction:** High tibial osteotomy (HTO) is effective in treating isolated medial osteoarthritis of the knee, but subsequent deterioration is inevitable, and total knee arthroplasty (TKA) is then an option. The present study sought to compare TKA following medial opening-wedge HTO (OW-HTO) versus lateral closing-wedge HTO (CW-HTO) in terms of intraoperative data and clinical results. The study hypothesis was that there is no significant difference in clinical results or complications in TKA following OW-HTO or CW-HTO.

**Material and method:** A retrospective multicenter (9 centers) study was conducted for the French Society of Orthopedic Surgery and Traumatology (SoFCOT), including 135 TKAs following HTO (58 OW and 77 CW) at a minimum 5 years' follow-up. Mean interval between HTO and TKA was 134 months and was longer in case of CW-HTO ( $P < 0.0001$ ). Mean age at TKA was 65.4 years and older in case of CW-HTO ( $P = 0.021$ ). Tibial slope was greater in case of OW-HTO ( $P = 0.024$ ). Prior to TKA, 55.7% of patients could walk without canes, 98.4% found stairs difficult or impossible and only 19.1% could manage a walking distance greater than 1000 m. Mean flexion was 110°; 54.2% of patients showed frontal knee stability and 87.8% sagittal stability; 60.1% had a mechanical axis in varus, without difference according to OW- or CW-HTO.

**Results:** Hardware was almost systematically removed (in 98.5% of cases): in the same step for OW-HTO ( $P = 0.018$ ) or often in 2 steps for CW-HTO. The primary approach was generally re-used (54.2%), but less frequently in the CW-HTO group ( $P = 0.0004$ ). Lateral or medial ligament release was not associated in respectively 78.2% and 79.7% of cases. The TKA implant was usually without stem (87.2%) and was fitted using a conventional technique (74.4%). At a mean 87 months' follow-up, 78.5% of patients could walk without canes, stairs were still difficult or impossible for 67%, and 74.1% could now walk further than 1000 m; mean flexion was 110.5°. Overall, 91.5% of patients showed frontal knee stability and 98.2% sagittal stability, without difference according to OW- or CW-HTO. There were 15 complications within 3 months, more often in the OW-HTO group (12.3%) although not significantly, and with no difference in severity. Late complications comprised loosening (5.5%) and infection (3.6%) and were more frequent in the CW-HTO group (12%) ( $P < 0.05$ ).

**Discussion:** The study hypothesis was partially confirmed. The only technical differences concerned hardware removal, often performed in two steps in case of CW-HTO, and TKA approach, which differed from the primary approach in case of CW-HTO. Clinical results were comparable between OW- and CW-HTO, but late complications were more frequent in the CW-HTO group.

**Level of evidence:** III; comparative retrospective study.

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## 1. Introduction

High tibial osteotomy (HTO), by opening wedge (OW-HTO) or closing wedge (CW-HTO), is effective in treating medial osteoarthritis of the knee in young subjects [1], without difference between the two types of osteotomy [2]. Results are satisfactory, but longer-term deterioration is unavoidable [3,4]. Khoshbin et al. [5] reported 67% 10-year survival in 2671 HTOs, with risk factors comprising age > 46 years, female gender, comorbidity and history of arthroscopy.

Surgical revision is thus necessary, usually in the form of total knee arthroplasty (TKA). Insall et al. [6] reported a 23% rate of TKA at 10 years after HTO.

TKA is reputed to be difficult following HTO, requiring management of the previous scar, extra-articular deformity, possible residual material, patellar height and ligament balance. Systematic literature reviews, meta-analyses and large-scale registries either find no difference between primary TKA and TKA following HTO or else report higher complications rates following HTO [7–16]. There have been few studies comparing TKA following OW-HTO or following CW-HTO. Han et al. [7], in a systematic literature review, reported no difference.

The present study sought to compare TKA following medial OW-HTO versus lateral CW-HTO in terms of intraoperative data, clinical results and complications. The study hypothesis was that there is no significant difference in clinical results or complications in TKA following OW-HTO or CW-HTO.

## 2. Patients and method

### 2.1. Series

A retrospective multicenter study was conducted for the French Society of Orthopedic Surgery and Traumatology (SoFCOT) as part of the November 2016 symposium, including 135 TKAs following HTO performed over a 5-year period from January 1, 2005 to December 31, 2009. Nine centers participated.

Inclusion criteria comprised: TKA after OW-HTO or after CW-HTO (whatever the model of TKA), with at least 5 years' follow-up after TKA.

Exclusion criteria comprised:

- femoral osteotomy;
- revision of osteotomy by unicompartmental implant;
- revision of osteotomy;
- tibial medial closing-wedge;
- tibial lateral opening-wedge.

**Table 1**  
Description of the series at the time of TKA.

	Full series	TKA after OW-HTO	TKA after CW-HTO	P (OW/CW)
n	135	58	77	
Female	73 (54%)	32 (55.2%)	41 (53.2%)	NS
Age (years)	65.4	63.2	67	P=0.021
Weight (kg)	85.5	84	86.7	NS
Unassisted walking	75/131 (55.7%)	35/58 (60.3%)	40/77 (51.9%)	NS
Stairs impossible	40/130 (30.7%)	17/57 (29.8%)	23/73 (31.5%)	NS
Stairs difficult	88/130 (67.7%)	39/57 (68.4%)	49/73 (67.1%)	NS
Walking distance > 1000 m	25/131 (19.1%)	12/58 (20.7%)	13/73 (17.8%)	NS
Not leaving the house	12/131 (9.2%)	8/58 (13.8%)	4/73 (5.5%)	NS
Mean flexion (°)	110° (70 to 140. med 110)	110° (75 to 140. med 110)	108° (70 to 140. med 110)	NS
Mean extension (°)	-5° (0 to -30. med 0)	-4° (0 to -20. med 0)	-6° (0 to -30. med 0)	NS
Frontal stability (<5°)	71/131 (54.2%)	34/58 (58.6%)	37/73 (50.7%)	NS
Sagittal stability (<5°)	115/131 (87.8%)	50/58 (86.2%)	65/73 (89%)	NS
Radiologic frontal axis (<180°)	77/128 (60.1%)	35/57 (61.4%)	42/71 (59.1%)	NS
Mean tibial slope (°)	3.6° (-10 to 20. med 0)	4.4° (-8 to 15. med 5)	2.7° (-10 to 20. med 3)	P=0.024

OW-HTO: opening-wedge high tibial osteotomy; CW-HTO: closing-wedge high tibial osteotomy; TKA: total knee arthroplasty; NS: non-significant.

The series comprised 135 patients (54% female): 58 OW-HTOs (43%) and 77 CW-HTOs (57%). Mean age was 65.4 years (range, 31–87; median, 64) and mean weight 85 kgs (range, 44–185; median, 82). Before the TKA, 55.7% could walk without canes; 98.4% found stairs difficult or impossible; 80.9% could walk only less than 1000m. Mean flexion was 110°; the knee was stable frontally in 54.2% of cases, and sagittally in 87.8%. The mechanical axis was in varus in 60.1% of cases (Table 1).

The two groups differed in as much as age was greater in the CW group ( $P=0.021$ ) and tibial slope greater in the OW group ( $P=0.024$ ) (Table 1).

### 2.2. Method

Clinical (flexion, stability, autonomy, walking distance, stairs, walking aids) and radiological data (HKA angle) were assessed at last follow-up. Pain was self-scored as “none”, “occasional” (once a month), “moderate” (once a week) or “severe” (every day). Results were considered “good” if autonomy (walking and stairs) and pain improved.

Laxity was assessed clinically according to the examiner's judgment. The mechanical axis was considered to be in varus if HKA < 180°. Loosening was defined by progressive radiolucency. Complications were noted: earlier than 3 months and at last follow-up.

Kaplan–Meier survival curves were drawn up for each HTO group, considering TKA revision as endpoint.

### 2.3. Statistical analysis

Statistical analysis was descriptive (range, mean, median). Qualitative variables were compared on Fisher's test and quantitative variables on Wilcoxon test for matched pairs. The significance threshold was set at  $P<0.05$ . Analysis used SAS software.

## 3. Results

### 3.1. Intraoperative data

Mean HTO-to-TKA interval was 134 months and was longer in the CW group ( $P<0.0001$ ) (Table 2).

TKA was in all cases posterior-stabilized without further constraint, but the model was left up to the surgeon.

The groups did not differ (Table 2) in terms of conventional or navigation-assisted technique, use of an extension stem or frequency of lateral or medial release.

**Table 2**  
Intraoperative data.

	Full series	TKA after OW-HTO	TKA after CW-HTO	P (OW/CW)
<i>n</i>	135	58	77	
Mean HTO-TKA interval (months)	134 (8–393, med 117)	104 (8–332, med 99)	155 (12–393, med 140)	<0.0001
Hardware removal	129/131 (98.5%)	55/56 (98.2%)	74/75 (98.7%)	NS
1-step ablation	62/131 (47.3%)	32/56 (57.1%)	30/75 (40%)	<i>P</i> =0.018
Primary incision re-used	71/131 (54.2%)	41/57 (71.9%)	30/74 (40.5%)	<i>P</i> =0.0004
No lateral ligament release	104/133 (78.2%)	43/58 (74.1%)	61/75 (81.3%)	NS
No medial ligament release	106/133 (79.7%)	46/58 (79.3%)	60/75 (80%)	NS
TKA with stem	17/133 (12.8%)	8/58 (13.8%)	9/75 (12%)	NS
Conventional TKA	99/133 (74.4%)	45/58 (77.6%)	54/75 (72%)	NS
TKA with navigation	34/133 (25.5%)	13/58 (22.4%)	21/75 (28%)	NS

OW-HTO: opening-wedge high tibial osteotomy; CW-HTO: closing-wedge high tibial osteotomy; TKA: total knee arthroplasty; NS: non-significant.

**Table 3**  
Comparison between pre-TKA and last follow-up clinical data for the full series.

	Pre-TKA	Last follow-up	P
<i>n</i>	135	135	
No or occasional pain	5/91 (5.5%)	88/118 (74.6%)	<0.0001
Unassisted walking	75/131 (55.7%)	91/116 (78.5%)	<0.0001
Stairs impossible	40/130 (30.7%)	10/115 (8.7%)	<0.001
Stairs difficult	88/130 (67.7%)	67/115 (58.2%)	<0.0001
Walking distance > 1000 m	25/131 (19.1%)	86/116 (74.1%)	<0.0001
Not leaving the house	12/131 (9.2%)	2/116 (1.7%)	<0.001
Mean flexion (°)	110° (70 to 140, med 110)	110.5° (80 to 130, med 110)	NS
Mean extension (°)	−5° (0 to −30, med 0)	−0.8° (−20 to 0, med 0)	<0.0001
Frontal stability (<5°)	71/131 (54.2%)	108/118 (91.5%)	<0.0001
Sagittal stability (<5°)	115/131 (87.8%)	115/117 (98.2%)	<0.005

NS: non-significant; pre-TKA: pre-total knee arthroplasty.

**Table 4**  
Outcomes: comparison of TKA after opening wedge osteotomy or closing wedge osteotomy.

	TKA after OW-HTO	TKA after -CW-HTO	P (OW/CW)
<i>n</i>	58	77	
No or occasional pain	42/56 (75%)	46/62 (74.2%)	NS
Unassisted walking	44/54 (81.5%)	47/62 (75.8%)	NS
Stairs impossible	2/55 (3.6%)	8/60 (13.3%)	NS
Stairs difficult	33/55 (60%)	34/60 (56.7%)	NS
Walking distance > 1000 m	41/55 (74.5%)	45/61 (73.8%)	NS
Not leaving the house	1/55 (1.8%)	1/61 (1.6%)	NS
Mean flexion (°)	111° (80 to 130, med 110)	110° (65 to 140, med 110)	NS
Mean extension (°)	0° (−10 to 0, med 0)	−1° (−20 to 0, med 0)	NS
Frontal stability (<5°)	50/55 (90.9%)	58/63 (92%)	NS
Sagittal stability (<5°)	53/54 (98.1%)	62/63 (98.4%)	NS
Radiologic varus (<180°)	31/53 (58.5%)	36/61 (59%)	NS

OW-HTO: opening-wedge high tibial osteotomy; CW-HTO: closing-wedge high tibial osteotomy; TKA: total knee arthroplasty; NS: non-significant.

The primary incision was more frequently re-used in the OW group (*P*=0.0004).

Hardware was removed in 98.5% of cases and in the same surgical step in 47.3%. One-step removal was more frequent in case of OW-HTO (*P*=0.018).

### 3.2. Clinical and radiological results

Table 3 shows overall results. At a mean 86.7 months, post-TKA (range, 2–136 months: 88.9 months [4–134] in OW-HTO and 84.9 months [2–136] in CW-HTO), there was significant improvement in pain, unassisted walking, stairs, walking distance, leaving the house, extension and stability.

There were no clinical or radiological differences between groups (Table 4).

### 3.3. Complications

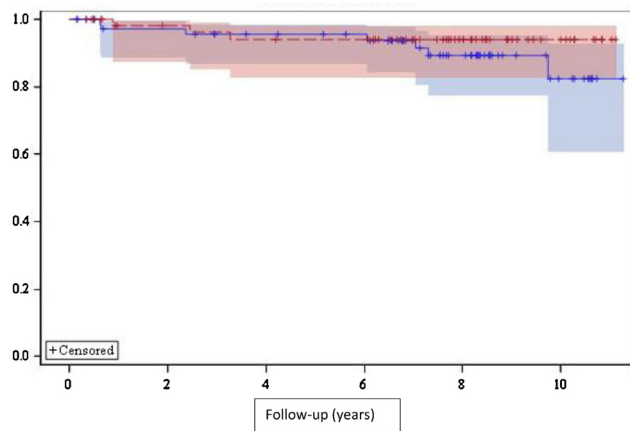
There were 15 early complications (Table 5). Although they were more frequent in the OW group (12.3% versus 8.3%), the difference was not significant (*P*>0.05).

**Table 5**  
Early complications (<3 months).

Complication	<i>n</i>	OW-HTO	CW-HTO
Skin necrosis	5	2	3
Common peroneal nerve injury	1	–	1
Posterior tibial nerve injury	1	1	–
Rotational polyethylene dislocation	1	–	1
Infection	3	2	1
Joint stiffness	4	3	1

OW-HTO: opening-wedge high tibial osteotomy; CW-HTO: closing-wedge high tibial osteotomy.

In the 111 files documenting late complications during follow-up, there were 11 cases of revision surgery: 6 for loosening (5.5%) at a mean 59 months, 4 for infection (3.6%) at a mean 34 months and 1 for a “technical problem”. Late complications were more frequent in the CW-HTO group (12% versus 6%; *P*<0.05).



**Fig. 1.** Survival curve. Blue: survival of total knee arthroplasty after closing-wedge high tibial osteotomy. Red: survival of total knee arthroplasty after opening-wedge high tibial osteotomy, 95% confidence intervals.

### 3.4. Survival curves

Ten-year survival was 94% (95% CI: [83–98]) in the OW-HTO group and 82% (95% CI: [61–93]) in the CW-HTO group, without significant difference ( $P=0.338$ ) (Fig. 1).

## 4. Discussion

Surgical habits for TKA after HTO were unchanged despite this context of HTO revision, with few stems used and mostly conventional surgery. In the CW group, hardware removal was mainly performed as a separate step and the primary approach was not mainly reutilized for TKA. Long-term clinical outcome was good and comparable between groups. Late complications, however, were more frequent in the CW group (12% versus 6%). The study hypothesis was thus partially confirmed.

The present results are comparable to those in the literature (systematic reviews, meta-analyses, comparative series and large-scale registries [7–16]) for TKA following HTO and primary TKA, with improved autonomy and conserved range of motion. Analyzing the literature in the light of levels of evidence, however, refines these conclusions.

Level-IV retrospective series confirm clinical improvement, but with a relatively high rate of complications (6–15%), revision surgery and malalignment [7–11], as in the present study. Gupta et al. [11] reported a 50-point improvement in IKS score and 32° improvement in flexion, but with a major complications rate of 14%. In contrast, at 15 years' follow-up, the Norwegian registry [8] found no difference in survival between primary TKA and TKA following HTO, although the proportions of reasons for revision differed: in primary TKA failure comprised 28% loosening or wear, 21% infection and 6% pain and in TKA following HTO 35% loosening or wear, 12% infection and 11% pain.

In level-III case-control studies comparing primary TKA versus TKA following HTO, results are less clear-cut and more controversial [12–16]. Clinical results were comparable in 2 reports [13,15] and better in primary TKA in 2 others [14,16]. Complications rates were comparable in 4 series [12–14,16], with identical revision rates in only 1 report [16] and good alignment in 3 [13–15]. The most striking report was by Efe et al. [14], with nearly 10° gain in flexion, a 12-point improvement in IKS score and a 50% lower revision rate in primary TKA.

Finally, Meding et al. [17] published an original study with 15 years' follow-up, comparing primary TKA and TKA following HTO in the same patient; in the 39 patients, there were no clinical or

radiological differences, with 100% 15-year survival in primary TKA and 97% in TKA following HTO.

The most frequent complications in the present post-HTO-TKA series were those commonly reported:

- skin complications;
- infection;
- stiffness.

There were no differences according TKA after OW-HTO or TKA after CW-HTO in our study, in agreement with the literature [7,18–20]. BastosFihlo et al. [18], comparing 117 TKAs after CW- and 24 after OW-HTO, found identical gain in range of motion and functional scores and comparable alignment correction, although with more frequent complementary intraoperative procedures in the CW group:

- 1 medial release;
- 1 anterior tibial tuberosity osteotomy;
- 1 quadriceps snip;
- more frequent posterolateral release [18].

Generally, all authors underline that TKA is more demanding after HTO, with more frequent complementary procedures [7,11,18–22]. This is attributed to architectural changes in the proximal tibia due to HTO: altered tibial slope, epiphyseal enlargement, metaphyseal malunion, possible lateral impingement by the tibial base in CW-HTO, and change in patellar height [2,7,15,23,24], as well as vascular risk in CW-HTO [25]. The recent introduction of personalized cutting-guides in OW-HTO has reduced architectural alteration in tibial slope, improving reproducibility [26]. The present study did not confirm these technical findings, but did highlight the fact that hardware removal tended to be performed in a separate step in the CW group and with a new incision for TKA. This was not reported by Han et al. [7] or Preston et al. [19], who found no difference according to the approach used for revision TKA.

Despite these frequently highlighted technical issues, the literature shows that a gliding prosthesis without adding a stem is usually enough to stabilize the knee [11,21,27–31]. The rationale for posterostabilization is that there is frequent posterior cruciate ligament failure, especially in case of severe bone defect. Posterostabilization improves knee stability and clinical outcome. The present study confirmed these findings. Navigation may be useful [15] but was not used in most of the present cases. The inclusion period was too early for the use of personalized cutting guides to be analyzed.

The study involved certain limitations. The retrospective multicenter design could have incurred a risk of missing data and variation in techniques and practices, but in fact this did not happen. The multicenter design, on the other hand, enabled a large series to be included, indeed one of the largest in the literature for TKA after HTO. The minimum 5-year follow-up was sufficient to meet objectives and test the study hypothesis. The lack of functional scoring and precise radiologic assessment was another limitation; but comparative study on the same set of technical and clinical criteria limited bias.

## 5. Conclusion

The present series of TKA following HTO confirmed that clinical outcome is good, with no differences between CW- and OW-HTO, except for more frequent late complications with CW-HTO. In case of CW- compared to OW-HTO:



- hardware removal is more frequently performed in two steps;
- the TKA approach is more often not the primary HTO approach.

### Disclosure of interest

ME: consultant for Depuy-Synthes, Lepine, NewClip.

AD declares that he has no competing interest.

PV: consultant for Medacta.

SLe: consultant for Ceraver.

FB: consultant for Amplitude Serf.

PB: consultant for Stryker and Depuy-Synthes.

SLu: consultant for Medacta and Smith&Nephew, institutional research support for Amplitude and Tornier.

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MC: consultant for Ceraver.

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