

CHANGES OF KNEE JOINT AND ANKLE JOINT ORIENTATIONS AFTER MEDIAL OPEN WEDGE HIGH TIBIAL OSTEOTOMY

By

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ABSTRACT

Background: Varus knee is a common deformity of the knee joint, which is usually accompanied by osteoarthritis, especially the medial compartment. High tibial osteotomy is a good solution for varus knee by transferring the load from the medial compartment to the more healthy lateral compartment slowing the progression of osteoarthritis.

Objectives: To assess the changes of knee joint and ankle joint orientations after medial open wedge high tibial osteotomy.

Patients and Methods: This prospective study was done on a consecutive sample of 20 patients who were admitted to Al-Azhar University Hospital during the period between October 2017 and October 2019 with varus knee. Exclusion criteria were severe osteoarthritis, periarticular fractures, cruciate ligament insufficiency, previous operations of the knee and inflammatory arthritis. All patients had undergone medial open wedge high tibial osteotomy after giving informed consents. Patients were followed up for 6 months.

Results: Preoperatively mTFA was -9.33° , TPI was -6.38° , KJLO was -0.40° , AJLO was 7.6° , PH was 0.93 and PTS was 7.53° . Their postoperative measurements changed to 1.75° , 2.5° , 2.03° , -0.03° , 0.86 and 8.93° respectively.

Conclusion: After medial open wedge high tibial osteotomy, posterior tibial slope and tibial plateau inclination increased, patellar height decreased, ankle joint orientation line became more parallel to the ground and knee joint orientation line became more laterally tilted.

Keywords: Open wedge high tibial osteotomy, varus knee, osteoarthritis.

INTRODUCTION

High tibial osteotomy (HTO) is a frequent realignment procedure for patients with symptomatic medial tibiofemoral (TF) osteoarthritis (OA) of the knee with varus malalignment (W-Dahl *et al.*, 2012).

Varus malalignment was reported to accelerate progression of medial

compartment OA of the knee and to aggravate symptoms in such patients (Sharma *et al.*, 2013). Therefore, HTO is considered to be a biomechanically sound joint preserving option for relatively younger patients with varus knee OA (Lee and Byun, 2015).

The goals of HTO are two folds:

1. To reduce knee pain by transferring weight-bearing loads to the relatively unaffected lateral compartment in varus knees.
2. To delay the need for a knee replacement by slowing or stopping destruction of the medial joint compartment (*Lee and Byun , 2012*). On the other hand, HTO has a potential biomechanical disadvantage that the procedure can lead to abnormal joint line orientation of the knee. HTO directly changes only the tibial geometry, thus the tibial plateau inclination (TPI) can become abnormally valgus which can eventually lead to abnormal knee joint line orientation (KJLO) (*Amis, 2013*).

In this study, we tried to assess the radiological changes of knee joint and ankle joint orientations by taking different measurements before and after performing the HTO that were directly and indirectly influenced by the operation.

PATIENTS AND METHODS

This study was approved by the Ethical Committee of Al-Azhar University. A total of 20 patients with symptomatic varus knee treated in Al-Azhar University Hospitals through the period from October 2017 to October 2019 using open wedge high tibial osteotomy. All patients signed informative consents. There were 12 males and eight females with a mean age of 34.5 years (20-52 years). Of the 20 patients, 12 had their right knee affected, while eight patients had their left knee affected.

All patients presented by pain of inner side of the knee. By examination, varus malalignment was observed. AP standing X-ray of knee revealed different grades of medial sided osteoarthritis and sometimes no radiological findings were found. Further long standing whole limbs X-ray demonstrated deviated mechanical axis of lower limb to medial side and varus orientation of mechanical tibio-femoral angle.

Diagnostic knee arthroscopy was performed pre-osteotomy for evaluation of lateral knee compartment status. Through longitudinal incision in the medial proximal third of the tibia, medial open wedge high tibial osteotomy (OWHTO) was performed. Varieties of plates (Tomofix, Puddu and Assal toothed plates) were used to secure the osteotomy. Patients were advised to use hinged knee brace for six weeks with gentle active exercises and absolute non weight bearing for at least six weeks followed by partial weight bearing for another six weeks.

The degree of the targeted correction was determined by the technique described by Murphy (*Robinson et al., 2011*). The desired new mechanical axis line was first drawn on the X-ray film from the center of the femoral head passing through the desired point in the medial third of the lateral tibial plateau. The line was continued out to a theoretical point VA (virtual ankle) at the level of the patient's ankle joint. The line of the intended tibial osteotomy was then drawn. A further line (line 1) was drawn from the center of the tibial surface of the talus to the anatomical correction axis (ACA) at the lateral edge of the proposed tibial osteotomy. A final line (line 2) was drawn

from the ACA to the VA point. The angle (h) between line 1 and line 2 is the angle

of the correction (**Fig.1**).

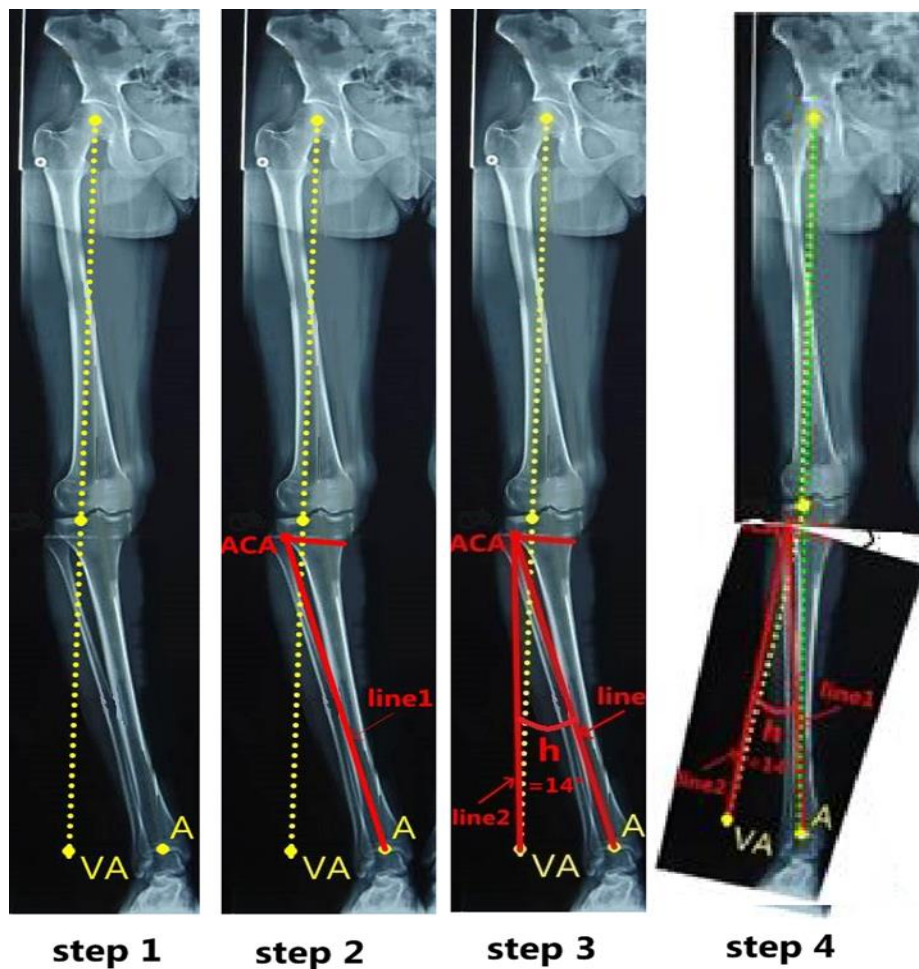


Figure (1): Method of planning the magnitude of the opening wedge, H hip, K knee, A ankle, VA virtual ankle, ACA anatomical correction axis

Six measures were used to evaluate radiological changes of knee and ankle orientations after OWHTO.

Mechanical tibiofemoral angle: It is the angle formed when the line that forms the

mechanical axis of the femur is extended to form an angle with the tibial mechanical axis (**Fig. 2**).



Figure (2): Measuring mechanical tibiofemoral angle

The knee joint line orientation (KJLO) relative to the ground angle: It is the angle between the line connecting the mid-points of the medial and lateral knee joint space, and a horizontal line on radiographs that was parallel to the floor; a negative value was given when the mid-joint space line tilted medially relative to the horizontal line (Fig. 3).

The ankle joint line orientation (AJLO) relative to the ground angle: It is the angle between the tangent to the subchondral plate of the talus and the horizontal line on radiographs that was

parallel to the floor; a negative value was given when the tangent of the talus surface tilted medially relative to the horizontal line (Fig. 3).

The tibial plateau inclination (TPI) angle: It is the angle between the mechanical axis of the tibia and the tangent to the subchondral plate of the tibia - 90 thereby a negative value was assigned to varus orientation of the tangent relative to the tibial mechanical axis (Fig. 3).



Figure (3): measuring TPI, KJLO and AJLO.

Patellar height (PH): Insall and Salvati method was used in this study which is a simple ratio between the length of the patellar tendon and that of the patella on the lateral X-ray of the knee in which the length of the patellar tendon (LT) was measured on its deep posterior surface from the lower pole of the patella

to its insertion on the tibial tubercle (Insall And Salvati.,1971). The length of the patella (LP) is defined as the greatest diagonal length of patella bone. The Insall–Salvati ratio is LT/LP with a mean normal ratio of 1.0 (0.8 to 1.2) is easy to remember (Fig. 4).



Figure (4): Length of patellar tendon (LT), Length of patella (LP), Ratio = LT/LP

Posterior tibial slope (PTS): It was measured as the angle created by a tangential line of the tibial plateau and tibial sagittal axis on lateral X-ray. The tangential line of the tibial plateau was defined as the line passing through the

highest anterior and posterior points of the tibial plateau. The sagittal axis was defined as the straight line connecting midpoints of outer cortical diameter at 5 and 15 cm distal to the knee joint (Fig.5).



Figure (5): Measuring posterior tibial slope

Statistical analysis of the data:

Data were fed to the computer and analyzed using IBM SPSS software package version 20.0. (Armonk, NY: IBM Corp). Quantitative data were described using mean, standard deviation. Spearman coefficient to correlate between two distributed abnormally quantitative variables. Significance of the obtained results was judged at the 5% level.

The used tests were:

1. Wilcoxon signed ranks test for abnormally distributed quantitative variables, to compare between two periods.
2. Paired t-test for normally distributed quantitative variable, to compare between two periods.

RESULTS

The mean value of preoperative mTFA was 9.33° varus orientation while, TPI revealed medial tilting by mean value of 6.38°, KJLO was -0.40°, AJLO was 7.6°, PH was 0.93 and PTS was 7.53°. Six months postoperative all measurements were reassessed and were found that the mean value of mTFA revealed statistical significant change to 1.75° valgus orientation (P >0.001), while TPI changed significantly to lateral tilting by a mean

value of 2.50° (P >0.001). Regarding joint orientation lines, both KJLO and AJLO showed statistically significant changes. KJLO changed to the mean value of 2.03° lateral tilting while AJLO changed to a medial tilt of a mean value of 0.03° (P >0.001). Furthermore PH significantly decreased to 0.86 (P >0.001). Regarding PTS, it showed significant increase to a mean value of 8.93° (P >0.001) (**Table 1**)

Table (1): Preoperative and postoperative mean values and standard deviations of studied measures (n=20)

Parameters Measures	Preoperative	Postoperative
mTFA	-9.33 ±3.97	1.75 ±2.29
TPI	-6.38 ±2.35	2.50 ±2.43
KJLO	-0.40 ±1.67	2.03 ±2.07
AJLO	7.60 ±3.95	-0.03 ±3.18
PH	0.93 ±0.07	0.86 ±0.07
PTS	7.53 ±1.14	8.93 ±1.15

It was found that there was a positive statistical correlation (P < 0.001) between change of mTFA and change of TPI. This occurs because TPI value increases with the increase of the correction angle. It was also found that change of mTFA has a

positive statistical correlation (P = 0.01) with AJLO. This is because the valgus compensation of ankle joint that happens in cases of varus knee and after correction of varus by valgus osteotomy there would be neutralization of AJLO (**Table 2**).

Table (2): Correlation between change of TFA and change of different parameters (n = 20)

Parameters	Changes of TFA	r _s	P
TPI		0.853*	<0.001*
KJLO		0.334	0.150
AJLO		0.560*	0.010*
PH		-0.281	0.231
PTS		-0.489*	0.029*

rs: Spearman coefficient

DISCUSSION

Dragoslaveanu et al. (2014) studied the effect of high tibial osteotomy on the posterior tibial slope (PTS) on patients in which the mean value of mTFA changed from a varus deviation of 5.72° preoperatively to a postoperative mean value of 3.03° valgus, and the value of PTS changed from 7.98° to 9.22° after operation. Their results were consistent with the results of our study as the value of PTS increased significantly after performing open wedge HTO.

Oh et al. (2016) stated that the mean value of mTFA preoperatively was 6° varus, and it became 3.3° valgus postoperatively. The value of TPI was -4.7° preoperatively, and changed to 2.7° postoperatively. Regarding knee joint orientation line and ankle joint orientation line, KJLO changed from -0.7° to 1.37° and AJLO changed from 6.3° to -0.25° . In the meantime PTS value increased from 7.8 before operation to 10 after operation. All these results were consistent with our results regarding the change of TPI, the change of KJLO which became tilted laterally, the change of AJLO which became tilted medially and the change of PTS that showed slight increase.

Lee et al. (2015) studied the changes of the orientations of the knee and ankle joints after performing high tibial osteotomy in varus malalignment of the knee in which the mean preoperative value of TPI was -2° , and it changed to 7° postoperatively which was consistent with our study. Also, KJLO became tilted more laterally, and AJLO became tilted medially.

Akamatsu et al. (2018) studied the effect of increased coronal inclination of

the tibial plateau after opening wedge high tibial osteotomy and found that the mean preoperative value of TPI was -5.35° and changed to 5.35° postoperatively, and KJLO changed from 0.30° to 4.45° after operation. The results of this study were consistent with the results of our study.

Regarding the change of PH after open wedge HTO, several studies in the literature discussed it. *El-Azab et al. (2010)* studied the change of patellar height and posterior tibial slope after open and closed wedge high tibial osteotomy and in that study the mean preoperative value of PH in the OWHTO group changed from 1.24 to 1.19 postoperatively. *Amzallag et al. (2013)* stated that patellar height decreases after opening wedge osteotomy and increases after closing-wedge osteotomy. The mean value of PH preoperatively was 0.98 and changed postoperatively to 0.88. The results of those studies showed a decrease of the value of PH and that was consistent to the results of our study.

Elsersawy et al. (2017) found that the mean value of PTS preoperatively was 8.33 and changed postoperatively to 8.6 showing little increase. However, in this study the increase was more significant.

By reviewing the mentioned studies, it was found that the postoperative mTFA ranged from 3.03° to 4.13° valgus, while our study revealed a mean postoperative mTFA of 1.75° valgus which was the least among others. However, the preoperative mean value of mTFA of our study was 9.33° which was the highest value of all mentioned studies. The value of TPI increased in the current study and in all mentioned studies by a value less than that of the increase of mTFA. The explanation

for this finding could be that realignment by HTO resolves abnormal lateral joint space opening. KJLO was getting tilted laterally after HTO, while ALJO was getting tilted medially. On the other hand the mean value of PH decreased, while the mean value of PTS increased after performing HTO.

CONCLUSION

After open wedge high tibial osteotomy (OWHTO), posterior tibial slope (PTS) slightly increases even with precautions taken to control the increase of PTS. After high tibial osteotomy the knee joint line orientation relative to the ground (KJLO) changed significantly less than did the anatomical geometry of the proximal tibia because of compensatory changes of the ankle joint line orientation relative to the ground (AJLO). The postoperative change in the tibial plateau inclination (TPI) i.e., the amount of correction by osteotomy, was less than the change of the mechanical tibiofemoral angle (mTFA).

After HTO, patellar height (PH) slightly decreased because the patellar tendon remains inserted in the distal fragment and moves distally in relationship to the joint line when the osteotomy is opened. The patella is thus lowered in relationship to the joint line. HTO changed the relative AJLO more than the KJLO because of the longer lever arm. The relative AJLO became more parallel to the ground; this phenomenon may improve biomechanics of the ankle joint by permitting more even distribution of the weight on the ankle joint.

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التغيرات في محور مفصلي الركبة و الكاحل بعد الشق الإسفيني المفتوح للجزء الأنسي لأعلي عظم الظنوب

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خلفية البحث: الركبة الفحجاء هي تشوه شائع في مفصل الركبة والتي غالباً ما تترافق مع الفصال العظمي وخاصة في القسم الأنسي. الخزع العظمي العلوي للظنوب يعتبر حل جيد للركبة الفحجاء عن طريق تحويل الحمل من الغرفة الأنسية إلى الغرفة الوحشية الأكثر صحة وبالتالي إبطاء تطور الفصال العظمي.

الهدف من البحث: تقييم التغيرات التي تطرأ على إتجاه مفصلي الركبة والكاحل بعد عملية الخزع العظمي المفتوح لأعلي الجزء الانسي من عظم الظنوب.

المرضى وطرق البحث: تمت هذه الدراسة المستقبلية على مجموعة من 20 عينة من المرضى على التوالي والذين كانوا قد قبلوا في مستشفيات الأزهر الجامعية خلال الفترة بين أكتوبر 2017 وأكتوبر 2019 ممن يعانون من الركبة الفحجاء. معايير الاستبعاد تتضمن: فصال عظمي شديد وكسور حول مفصل الركبة، ضعف الرباط الصليبي، عمليات سابقة في الركبة والتهابات المفاصل الالتهابية. كل المرضى قد خضعوا لعملية الخزع العظمي المفتوح لأعلي الجزء الانسي من عظم الظنوب بعد الحصول على موافقتهم واستمرت متابعة المرضى لمدة 6 اشهر.

نتائج البحث: قبل إجراء الجراحة كانت نتائج القياسات بالنسبة للزاوية الطنوطية الفخذية الميكانيكية 9.33° ، زاوية ميلان الهضبة الطنوطية 7.6° ، 6.38° ، خط اتجاه مفصل الركبة -0.40° ، خط اتجاه مفصل الكاحل 7.6° .

ارتفاع الرضفة: 0.93° والفرجة النبوية الخلفية 7.53° وقد تبدلت قياساتهم علي التوالي الي: 1.75°, 205°, 2.03°, -0.03°, 0.86° و 8.93°.

الإستنتاج: بعد عملية الخزع العظمي المفتوح للجزء الانسي لأعلي عظم الظنوب إزدادت الفرجة الظنوبية الخلفية وكذلك ميل الصفيحة الظنوبية قد إزداد وإرتفاع الرضفة قد إنخفض وإتجاه مفصل الكاحل أصبح موازي أكثر للأرض وإتجاه مفصل الركبة اصبح مائلا للوحشي أكثر.

الكلمات الدالة: محور مفصلي الركبه والكاحل – الشق الاسفيني المفتوح – عظم الظنوب .