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## Comparison of Genu Varum Treating Results Using Open and Closed Wedge High Tibial Osteotomy

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**Abstract:** High tibial osteotomy methods include open and closed wedge techniques. The study aims at comparing results of osteotomy methods in patients suffering from genu varum deformity. In a cohort study, 32 patients with genu varum deformity (42 knees) were evaluated. They were divided into two groups and matched according to age and gender. The patients were treated with open and closed wedge osteotomy. After surgery, they were followed up and compared for 6 months. Thirty two patients with genu varum deformity (10 cases of bilateral deformity (31.2%) including 25 women (87.2%) and 7 men (21.8%) were studied. Incidence of complications was the same after open and closed wedge osteotomy operation (12.5%). Patients overall satisfaction from open and closed wedge methods was 87.5 and 75%, respectively. There was statistically significant difference between two groups considering operation duration, weight bearing duration and return to routine activities ( $p < 0.001$ ). There was no difference in other parameters including varus angle correction, Lysholm score Tegner activity as well as Insall Salvati index. This study demonstrated that there is no difference between two osteotomy methods considering patients' clinical outcomes and both methods are successful in final treatment results.

**Key words:** High tibial osteotomy, open wedge osteotomy, closed wedge osteotomy

### INTRODUCTION

Genu varum is a kind of knee deformity and is identified with change of the organ natural direction such that center of knee joint is located at exterior part of the organ mechanical axis. In this deformity, patients' knees have a distance at standing position and have a parenthesis-like view (Lotti *et al.*, 2013; Marmotti *et al.*, 2012; Sadighi *et al.*, 2011; Stevens and Novais, 2012). Several factors including vitamin D deficiency at childhood, congenital factors, calcium and phosphorus metabolism disease, trauma, infection as well as physiologic factors are involved in developing this complication (Goldust *et al.*, 2012; Goldust *et al.*, 2013a; Haviv *et al.*, 2012; Park *et al.*, 2012). Genu varum is not desirable for people considering appearance and aesthetic issues. Also, it leads to problems in walking and pain of medial knee due to patella inappropriate movement in severe cases. In most cases, the deformity gradually destroys cartilage of knee joint. Appearing of this delayed effect is a result of unequal pressure imposed on medial and distal compartments of the knee (Mohebbipour *et al.*, 2012; Pasquier *et al.*, 2012; Pei *et al.*, 2011; Sadehpour *et al.*, 2011). High tibial osteotomy is one of the surgical methods widely used to treat osteoarthritis

and genu varum deformity of knee joint. There are extensive surgical techniques including open wedge, closed wedge and valgisation osteotomy. Open and closed wedge methods are two common ways to treat osteoarthritis and genu varum deformity (Brosset *et al.*, 2011; Goldust *et al.*, 2011; Goldust *et al.*, 2013b; Saragaglia *et al.*, 2012). Closed wedge high tibial osteotomy is a common and fixed surgical method for treating medial knee compartment osteoarthritis and correcting deformities such as genu varum. This surgical technique was first introduced by Coventry in 1969 (Dulka *et al.*, 2011; Goldust *et al.*, 2013c; Ogbemudia *et al.*, 2012). In this technique, osteotomy is conducted from high tibial tubercle as a wedge from exterior part and leads to decrease of the force imposed to medial compartment, decrease of complications, mitigate the medial knee joint compartment and improve knee movements and function (Goldust *et al.*, 2013d; Golfurushan *et al.*, 2011; Pascale *et al.*, 2011; Prasad and Zahn, 2012). Although, high tibial osteotomy is generally regarded as an efficient treatment method, there is uncertainty considering how to conduct osteotomy and select the patients for each of the available surgical methods. Choosing from open and closed wedge method, selecting graft for the open wedge method, fixation

methods and whether high tibial osteotomy affects knee joint arthroplasty results are of cases have attracted orthopedic surgeons attention (Milan *et al.*, 2011; Schroter *et al.*, 2011; Shim *et al.*, 2013; Vafae *et al.*, 2012). Considering that correcting the varus gonarthrosis using osteotomy at prima tibial is of common surgeries and two available surgical methods are used depending on the surgeon's choice, the study aims at comparing results of open and closed wedge methods (Coventry method) in correcting genu varum.

## **MATERIALS AND METHODS**

**Subjects:** This cohort study was conducted on two groups of patients with genu varum deformity of knee joint at Shohada Training and Therapeutic Center of Tabriz University of Medical Sciences and training department of orthopedic surgery from Dec., 2010 to Dec., 2012. Based on indications, the patients were candidate of osteotomy method to treat the problem. After obtaining written letter of satisfaction, the qualified and interested patients entered the study. This study was approved by ethic committee of Tabriz University of medical sciences.

**Inclusion criteria:** The inclusion criteria were patients' personal satisfaction to participate the study, lack of internal diseases, lack of fracture records in lower extremities, lack of surgical records on knee joint, lack of muscular lesions on the lower extremity.

**Methodology:** In this study, 32 patients with genu varum and candidate to surgery were randomly divided into two equal groups and underwent open and closed high tibial osteotomy. These two groups were matched considering age, gender and Body Mass Index (BMI). Exclusion criteria included damage of articular ligaments or capsules, after-trauma arthrosis, rheumatic diseases as well as impossibility of the patient's follow-up at least for 6 months after surgery. Range of gonalgia at standing and activity position was evaluated using VAS and Lysholm and the Tegner Activity questionnaire score, BMI, knee plain radiography at standing position (both knees), anterior and posterior slope as well as patella height (based on Insall Salvation index), stability of lateral and medial collateral ligaments and knee joint range of motion (ROM) (in examination) were determined before surgery. All the mentioned cases were reevaluated one week and 6 months after surgery. Additionally, time of return to work or routine activities, complete weight bearing time and patients' satisfaction were determined. Also, surgery duration, complications observed in surgery or after it as

well as follow-up period will be determined. Open and closed wedge osteotomy has been conducted on the patients. In open wedge method, the skin is cut at medial distal high fibula and osteotomy is started from medial part to tibia tubercle with a 3.5 cm distal distance to articular line and lasts toward tip of high fibula end. Proximal and distal parts of the bone are opened from medial part considering correction angle and the bone is grafted at the same empty wedge like space depending on different patients. Finally, tibia proximal is fixed using L or T plates. Based on different individuals or autograft, the bone graft used in this method is taken from the patient's pelvis. It lacks any special complication. Or, artificial allograft is used which is confirmed by US Food and Drug Administration (FDA) and no special complication has been mentioned. In closed wedge method, the skin is cut at exterior part of high bone and the bone, in the form of a wedge with an external base and at the corrected size obtained from the formula is removed using a special formula. Then proximal and distal ends of the bone are closed together and fixed using a plate. In this method, bone graft has not been used (size of wedge base = bone diameter  $\times$  correction angle  $\times$  0.02). Disordering variables of the study include inflammatory muscular and skeletal diseases such as arthritis rheumatoid and fracture records which can be effective in treating results. It was tried to prevent interference in treating results through exact selecting of the patients. Also, all operation stages were conducted by the same person to prevent effects of the surgeon proficiency in treating results. The evaluated cases were compared in each group as well as between both groups before and after surgery.

**Statistical analysis:** The data obtained from the study was analyzed using descriptive statistical methods (frequency-percent, Mean  $\pm$  standard deviation). T-test (independent samples, paired samples) and Chi-Square or Fischer Exact test were used to compare quantitative and qualitative data, respectively. In all cases,  $p < 0.05$  was regarded meaningful.

## **RESULTS**

In this study, 32 patients with genu varum at 42 lower extremities were evaluated. Out of them, 10 patients (31.2%) suffered from bilateral and 22 (67.8%) from unilateral genu varum and 21 lower extremities were operated using closed wedge and 21 ones with open wedge method. There was decrease of articular space of medial compartment in 21 cases (65.6%). According to Table 1, there was no statistically difference between two groups considering demographic findings. Appearing of

Table 1: Demographic findings between two groups of patients treated with open and closed wedge osteotomy methods

Variable	Open wedge group (n = 21)	Closed wedge group (n = 21)	p-value
Gender (m/f)	13 (81.3%)/3 (18.8%)	12 (75%)/4 (25%)	0.2
Age (year)	36.5±8.1	35.1±9.7	0.4
Beauty complaint	15 (62.5%)	11 (68.8%)	0.1
Pain complaint	6 (37.5%)	5 (31.3%)	0.1
Type of genu varum			0.3
Bilateral	6 (18.7%)	4 (12.5%)	
Unilateral	10 (31.3)	12 (37.5)	

Table 2: Comparison of quantitative findings between two groups of patients treated with open and closed wedge osteotomy methods

Variable	Open wedge group (n=21)	Closed wedge group (n=21)	p-value
Before tibiofemoral angle (valgus)	13.7±2.6	14.9±3.6	0.500
After tibiofemoral angle (varus)	6.7±1.7	6.1±2.2	0.400
Lysholm score	64.6±17.5	62.6±17.3	0.700
Tegner activity score	7.7±2.6	7.06±2.4	0.400
Before tibia slope	9.03±3.04	7.9±1.9	0.100
After tibial slope	11.8±1.5	10.6±1.9	0.500
Insall Salvati Index	10.5±0.1	11.5±1.9	0.500
Operation duration	90±10.9	115±14.3	<0.001
Walking time (day)	12.5±3	32.5±2.5	0.010
Complete weight bearing time (day)	60.4±10.5	90.5±12	0.010
Time of return to routine activities (day)	90.5±5.5	170.5±20.5	0.020

complication at the time of surgery was the same for both open and closed wedge methods (2 cases (12.5%)). In both groups, there was 14 patients without any complication at the time of surgery. The complications created at open wedge method included two cases of intraarticular fracture occurring while fixating with screw. However, there was no neurovascular damage. There was one case of peroneal nerve damage as well as one case of intraarticular fracture in closed wedge surgery occurred at fixation stage. Complications were not observed at follow-up period of patients treated using open wedge method. One case of peroneal nerve paralysis was seen in those patients treated with closed wedge method. There was statistically significant difference between two groups considering satisfaction from scar and its size ( $p = 0.009$ ) such that 6 patients (37.5%) treated with closed wedge method were not satisfied from size of scar and skin incision. This is while all patients of the open wedge group were completely satisfied from the created scar and skin incision. In the group treated with open wedge method, 2 patients (12.5%) were generally dissatisfied because of continuing the pain. Dissatisfaction was observed in 4 patients (25%) of the group treated through closed wedge method (1 case because of nerve paralysis and 3 cases for continuous pain). Generally, satisfaction level was 87.5 and 75% in open wedge and closed wedge methods, respectively. Other qualitative variables measured between two groups have been stated in Table 2. According to this Table 2, surgery duration in

open wedge method was significantly shorter than that of the closed wedge method. There was no statistically meaningful difference between two groups before surgery and 6 months after surgery considering posterior slope (angle between tibial shaft and articulate surface in lateral radiography). The differences observed before and 6 months after surgery was meaningful ( $p < 0.001$ ). There was no meaningful difference between two groups considering functional score of Lysholm and Wallgren-Tegner Activity Score. According to Insall Salvati Index, no special change was observed in patella height before and after surgery in both open and closed wedge groups. Amount of deformity correction before and 6 months after treatment was statistically meaningful and changed from varus to valgus in both groups ( $p = 0.001$ ). As observed in Table 2, there was no difference between two groups considering pretreatment varus size and the valgus created after surgery. The operation time was 90±10.9 and 115±14.3 minutes in open and closed wedge groups, respectively. This difference was statistically significant ( $p < 0.001$ ). Time of walking with the aid of crutches as toe touch was averagely 12.5±3 and 32.5±2.5 days for open wedge and closed wedge patients. The difference was statistically meaningful ( $p = 0.01$ ). Also, complete weight bearing time in the open wedge group was 60.4±10.5 days and in the closed wedge one was 90.5±12 days. The difference was again significant ( $p = 0.01$ ). According to Table 2, the patients treated with open wedge method returned to their routine activities faster than those treated using closed wedge method.

## DISCUSSION

Medial knee osteoarthritis is associated with varus deformity and therefore, extra force imposed to the medial compartment. Proximal tibial osteotomy may change mechanical axis of the lower extremity and correct abnormal force imposed to the medial compartment (Pasquier *et al.*, 2012). Results of long-term follow up have introduced 2-8 degree of valgus correction as ideal for the mechanical axis. There are several reports considering osteotomy results of closed wedge method. But there are contractions regarding selecting of patients to be treated with each of the available osteotomy methods (Keyhani *et al.*, 2011; Ng *et al.*, 2010). Open wedge osteotomy has recently attracted more attentions. One of its reasons is lack of nervous complications occurring in closed wedge osteotomy. Peroneal nervous paralysis occurring in the closed wedge method is not seen in this method. Also, problems related to knee arthroplasty occurring after closed wedge osteotomy is not seen in

this technique. Therefore, this osteotomy method has been widely noticed by orthopedic surgeons (Madadi *et al.*, 2010; Niemeyer *et al.*, 2010). Theoretical advantages of open wedge osteotomy method to the closed wedge one include anatomical recovery better than bone graft to the medial compartment, capability of reaching the predictable correction at coronal and sagittal levels and capability of setting while surgery (Amer and Khanfour, 2010; Johari *et al.*, 2010). In different studies, there have been observed varied complications related to each of the surgical treatment methods. In a study conducted by Wu *et al.* (1995) the complications manifestation rate was 5.6% while it was 34% in a study conducted by Wu *et al.* (1995), Zhang *et al.* (2010). In the current study, complications appearing rate was about 12.5% which was similar to the previous ones. There was no difference between two surgical treatment methods. As reported in other studies, intra articular fractures were the most important complication of open wedge osteotomy occurring at fixation stage. The problem was solved in follow-up period and no complication was observed in patients treated with open wedge osteotomy at the end of the six month follow-up period. In patients treated with closed wedge osteotomy, complications prevalence was the same as the open wedge group but there was a difference regarding kinds of complications. One case of peroneal nerve paralysis was the most important complication in the group treated with this method. Also, there was one case of intraarticular fracture. Contrary to the patients treated with open wedge method, peroneal nerve paralysis was left during follow-up period (6 months after surgical treatment) and it was regarded as one of the weak points of this method. In closed wedge osteotomy conducted through cancellous bone, chance of nonunion or delayed union in more than open wedge osteotomy. According to results of our study, nonunion and delayed union was not observed in any patients of both groups after treatment and during follow-up period. The recovery rate was the same (El-Assal *et al.*, 2010; Lee *et al.*, 2010; Shiha *et al.*, 2009) describe the excellent treatment results after at least 10 years of follow up in 64% of patients treated with closed wedge osteotomy method (Shiha *et al.*, 2009). In the current study, these results have been, respectively observed in 87.5 and 75% of patients treated with open and closed wedge method considering patients mitigation and their satisfaction from treatment. Less satisfactory results in closed wedge method can be attributed to one case of peroneal nerve paralysis. Generally, there was no significant difference in the six-month follow-up period of the patients considering their clinical outcomes. In current study, operation duration in open wedge method was less than closed

wedge osteotomy. The difference was meaningful. This is another advantage of the open wedge osteotomy method and is possible even in patients suffering from cardiovascular problems and cannot bear long term operation. According to the findings of the studies, capability of early return to routine activities, weight bearing and walking are of other advantages of the open wedge method (Huten, 2009; Sim *et al.*, 2010). Tibial slope is one of the most important parameters affecting knee biomechanics. Tibial proximal medial interior cortex is inclined and three angle while distal cortex is vertical at tibial posterior surface. For this reason, open wedge osteotomy may lead to increase of tibial slope in contrary to the closed method resulting in decrease of tibial slope. The slope change leads to change of tibiofemoral contact point and as a result, increase of ALC ligament potential to bear more imposed force and decrease of knee extension (Staubli and Jacob, 2010; Zhang *et al.*, 2009). In the current study, tibial slope in the open wedge method was more than the closed one. But, the difference was not statistically significant and meaningful. There are contradictions in studies regarding correction rate of valgus angle (Gary and Richards, 2008; Saragaglia *et al.*, 2010) Also, more valgus angulation probably leads to imposing more force toward distal compartment and decreasing of medial compartment force. It cannot be accepted from beauty viewpoint. Ribeiro *et al.*, (2009) report that patellar bone decreases in all cases of patients treated with tibial proximal osteotomy. It is due to locating of articular surface around tibial tubercle in open wedge osteotomy (Ribeiro *et al.*, 2009). Schiedel *et al.* (2009) suggested decrease of patellar height 80% of cases. They also state that rate of the correction does not affect patellar bone height. In the current study and considering Insall Salvati index, there was no difference between two treatment groups considering decrease of patellar height after treatment. This is true in other studies, too.

## CONCLUSION

According to the results of this study, there is no difference between two methods of osteotomy considering patients' clinical outcome. Both methods are successful in final treatment results. However, open wedge osteotomy is more advantageous than the closed one considering less nervous complications, more quick recovery of the patients and their more satisfaction.

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