

## Comparing the Genu varum Correcting Results Using Classic and Modified Open Wedge High Tibial Osteotomy

Seyed Hamid Barzegar, Mohammad Ali Jafari

Department of Orthopaedics, Tabriz University of medical sciences, Tabriz, Iran  
[Dr.barzgar@yahoo.com](mailto:Dr.barzgar@yahoo.com)

**Abstract:** Surgical correction of genu varus should be performed as early as possible. Overload osteoarthritis, even without significant varus deformity of the knee, is a further indication for open-wedge high-tibial osteotomy. This study aimed at comparing the genu varum correcting results using classic and modified open wedge high tibial osteotomy. This clinical trial study was conducted on two groups of patients with genu varum deformity. 32 patients with genu varum and candidate to surgery were randomly divided into two equal groups and underwent classic and modified open wedge high tibial osteotomy. These two groups were matched considering age, gender, and BMI. Mean age of the patients was  $32.45 \pm 8.65$  years. 10 cases suffered from bilateral genu varum and 21 patients from one-lateral. There were 6 cases of intra articular fracture in open wedge method. They were fixed using screws during operation. However, there was not found any case of fracture in modified open wedge method. There was not any other postoperative complication (compartment syndrome), DVT vascular complications, knee rigidity, bedsores, and nonunion in modified or open wedge methods. Generally, both surgical methods can be used to correct deformity. Modified open wedge method is preferred to classic open wedge one considering lack of intraarticular fracture in this method since it can threaten long-term prognosis of the surgery.

[Seyed Hamid Barzegar, Mohammad Ali Jafari. **Comparing the Genu varum Correcting Results Using Classic and Modified Open Wedge High Tibial Osteotomy.** *J Am Sci* 2013;9(10s):96-101]. (ISSN: 1545-1003).

<http://www.jofamericanscience.org>. 18

**Keywords:** Genu varus; Modified open wedge high tibial osteotomy; Classic open wedge high tibial osteotomy

### 1. Introduction

Genu varum is a physical deformity marked by (outward) bowing of the leg in relation to the thigh, giving the appearance of an archer's bow. Usually medial angulation of both femur and tibia is involved. (Johari et al. 2010; Zhang et al. 2010) If a child is sickly, either with rickets or suffering from any ailment that prevents the due ossification of the bones, or is improperly fed, the bowed condition may remain persistent. Thus the chief cause of this deformity is rickets. (El-Assal et al. 2010; Lee et al. 2010) Skeletal problems, infection, and tumors can also affect the growth of the leg, sometimes giving rise to a one-sided bow-leggedness. The remaining causes are occupational, especially among jockeys, and from physical trauma, the condition being very likely to supervene after accidents involving the condyles of the femur. (Shiha et al. 2009; Sim et al. 2010) Generally, no treatment is required for idiopathic presentation as it is a normal anatomical variant in young children. Treatment is indicated when it persists beyond 3 and a half years old. In the case of unilateral presentation or progressive worsening of the curvature, when caused by rickets, the most important thing is to treat the constitutional disease, at the same time instructing the care-giver never to place the child on its feet. (Huten 2009; Staubli and Jacob 2010) In many cases this is quite sufficient in itself to effect a cure, but matters can be

hastened somewhat by applying splints. When the deformity arises in older patients, either from trauma or occupation, the only permanent treatment is surgery, but orthopaedic bracing can provide relief. (Zhang et al. 2009; Saragaglia et al. 2010) Despite the fact that common surgical techniques for the treatment of genu varum usually correct the malalignment in the affected knee, these methods have significant complications and cause problems in the long term. (Gary and Richards 2008; Ribeiro et al. 2009) Opening-wedge high tibial osteotomy is among the newer techniques for the treatment of genu varum. It aims to improve the pain and/or knee functions, through the correction of varus deformity. The technique has been used for many years, and is now consecrated in medical circles. (Schiedel et al. 2009; Zhang et al. 2008) Although opening-wedge high tibial osteotomy (HTO) is used to correct deformities, it can simultaneously alter tibial slope in the sagittal plane because of the triangular configuration of the proximal tibia, and this undesired change in tibial slope can influence knee kinematics, stability, and joint contact pressure. Therefore, medial opening-wedge HTO is a technically demanding procedure despite the use of 2-dimensional (2-D) navigation. (Saragaglia et al. 2008; Kraal et al. 2008) The aim of this study was to compare the genu varum correcting results using

classic and modified open wedge high tibial osteotomy.

## 2. Material and Methods

This clinical trial 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. 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. In this study, 32 patients with genu varum and candidate to surgery were randomly divided into two equal groups and underwent classic and modified open wedge high tibial osteotomy. These two groups were matched considering age, gender, and 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.

A. In classic 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. Then, 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 is fixed using proximal L or T plates. Artificial allograft is used which is confirmed by FDA and no special complication has been mentioned.

B. In modified open wedge method, before skin incision, two Eshtaimen pins (grade III) are inserted parallel to articular surface at subcondral bone area through television control (from medial to lateral). They are checked using X-ray. The rest stages are the same as above-mentioned classic technique. While osteotomy using saw, the saw contact the pins at the end of osteotomy path and prevents from intraarticular or lateral cortex fracture of tibia proximal area. It is one of advantages of this method.

## 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 significant.

## 3. Results

In this study, 32 patients with genu varum problems (42 affected lower limbs) were considered. Out of them, 10 cases suffered from bilateral genu varum and 21 patients from one-lateral. Also, 21 lower limbs were operated using modified open wedge and 21 ones using open wedge methods. Considering 10 patients with bilateral genu varum, 5 cases were operated using open wedge method in their both limbs and 5 ones underwent surgery using modified open wedge method. The study was consisted of 25 females and 7 males. Mean age of the patients was  $32.45 \pm 8.65$  years (Table 1).

**Table 1. Demographic findings between two groups of patients treated with classic and modified open wedge osteotomy methods**

Variable	Classic open wedge group (n=21)	Modified open wedge group (n=21)	P value
Gender (f/m)	(81.3%)13/(18.8%)3	(75%)12/(25%)4	0.24
Age (year)	30.54 $\pm$ 8.1	34.13 $\pm$ 9.7	0.43
Beauty complaint	(62.5%)15	(68.8%)11	0.12
Pain complaint	(37.5%)6	(31.3%)5	0.16

Main complication of the patients when they referred to the physician: 21 cases for appearance and 11 cases for pain. There were three patients with osteoarthritis symptoms of knee in X-ray graphy. There were 6 cases of intra articular fracture in open wedge method. They were fixed using screws during operation. However, there was not found any case of fracture in modified open wedge method. There was not any other postoperative complication (compartment syndrome), DVT vascular complications, knee rigidity, bed sore, and nonunion in modified or open wedge methods. General and spinal anesthesia were used in 8 and 24 patients, respectively. There was pre-operative knee pain in 11 patients. Out of them, 5 cases underwent open wedge surgery and normal pain was only seen in one patient during follow-up periods (one week and 6 months after surgery). Knee ROM was at

normal range in all patients before surgery as well as follow-up periods (one week and 6 months after surgery). There was slightly medial ligament laxity (MCL) in 16 operated lower limbs. The two cases were operated using modified open wedge method. There was not any case of medial ligament laxity in patients operated using open wedge method. Examination of peroneal nerves and posterior tibia indicates to their normalness both before and after surgery in all patients. There were symmetrical distal pulses in limbs of all patients in both surgical methods and follow-up periods. Postoperative follow-up visits referred to 9-10 degree of femoral tibial angle in varus patients. Postoperative follow-up visits (after one week and six months) demonstrated that femoral tibial angle was averagely 4-10 and 2-8 degree of valgus in the open wedge and modified open wedge methods, respectively. The posterior slop (the angle between tibia shaft and joint surface in LAT graphy) was about  $7.4\pm 5$  for the open wedge group. It reached to  $10\pm 7.1$  six months after operation. There was not any meaningful difference between two groups considering pre- and postoperative posterior slop. There was not any significant difference between these two groups considering patella height measured before and after operation based on Insall-Salvati Index. There was pre-operation deformity in all cases. Postoperative visits (after one week and six months) demonstrated that there was clinical deformity of the limb appearance in 6 cases of open wedge and 7 cases of modified open wedge although radiological tibio-femoral angles were corrected. Patients of both groups walked with the aid of crutches from about the 4<sup>th</sup> week. Full weight bearing (WB) time varied from 8<sup>th</sup> to 10<sup>th</sup> week in patients of both groups. Both groups returned to their work from the third month. Nine patients being operated using open wedge method were less satisfied due to continuation of pain and intra articular fracture. Also, 2 cases underwent modified open wedge surgery method were less satisfied due to pain. Out of 16 patients underwent open wedge operation, 15 cases interestingly recommended the method to their relatives while only 9 patients of classic open wedge method encouraged their relatives to use the same method. Patients of both groups were satisfied considering length of skin incision. Time spent for open wedge operation was averagely 40min-1h. It was 50-70min for the modified open wedge method. There was not any significant difference in this regard (Table2).

**Table 2. Comparison of quantitative findings between two groups of patients treated with classic and modified open wedge osteotomy methods**

Variable	Classic open wedge group (n=21)	Modified open wedge group (n=21)	P value
Before tibiofemoral angle (valgus)	13.7 $\pm$ 2.6	13.94 $\pm$ 3.68	0.54
After tibiofemoral angle (varus)	6.76 $\pm$ 1.72	6.14 $\pm$ 2.24	0.42
Lysholm score	64.66 $\pm$ 17.52	66.64 $\pm$ 17.36	0.74
Tegner activity score	7.73 $\pm$ 2.63	7.06 $\pm$ 2.46	0.43
Before tibia slope	7.42 $\pm$ 5.23	7.93 $\pm$ 1.93	0.14
After tibial slope	10.12 $\pm$ 7.12	10.68 $\pm$ 1.94	0.55
Insall Salvati Index	10.56 $\pm$ 0.16	11.57 $\pm$ 1.98	0.52
Operation duration (min)	50.24 $\pm$ 10.98	70.15 $\pm$ 14.3	<0.001
Walking time (day)	12.54 $\pm$ 3.22	10.53 $\pm$ 2.55	0.58
Complete weight bearing time (day)	60.44 $\pm$ 10.55	56.5 $\pm$ 12.34	0.35
Time of return to routine activities (day)	90.56 $\pm$ 5.57	80.58 $\pm$ 12.46	0.46

#### 4. Discussions

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.(Stevens and Novais 2012; Marmotti et al. 2013) 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.(Park et al. 2012; Haviv et al. 2012) 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.(Pasquier et al. 2012; Pei et al. 2011) Therefore, this osteotomy method has been widely noticed by orthopedic surgeons. 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.(Brosset et al. 2011; Saragaglia et al. 2012)

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., the complications manifestation rate was 5.6% while it was 34% in a study conducted by Schroter et al. (Wu et al. 1995; Schroter et al. 2011) Other studies have stated manifestation of kinds of complications of tibial osteotomy as 10-20%. (Shim et al. 2013; Keyhani et al. 2011) In our study, complications appearing rate was very low 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 but this problem is solved in modified open wedge osteotomy. According to the previously conducted studies, infection has been reported as 0.8-10.4% for the osteotomy. (Ng et al. 2010; Niemeyer et al. 2010) Similar to other surgeries, prevalence of kinds of infections are seen in lower extremities. In our study, no infection was observed in the patients. There was no difference between two methods considering the infection. 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. Madadi et al. studied 108 patients and followed them up for 22 months and proved efficiency of both treatment methods in correcting knee deformity and treating the patients. But it is stated that open wedge osteotomy method is better for patients requiring more fixation of medial ligament. (Madadi et al. 2010) According to the experiment of Lee et al., open wedge osteotomy is more advantageous than the closed one such that osteotomy at biplana is simply possible in this method in addition to simplicity of medial fixation using two metal plate and four screws. (Lee et al. 2010) Less invasion nature of the open wedge method in comparison with the closed one is another advantage of this method. The osteotomy can be easily conducted in old patients using open wedge method. (Saragaglia and Roberts 2005; Gall et al. 2005) 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. (Merian et al. 2005; Hinterwimmer et al. 2004) According to Dejour et al report, increase of tibial slope lead to increase of

posterior and interior cruciate ligament tension force. (Dejour et al. 1987) There are contradictions in studies regarding correction rate of valgus angle. Bauer et al. report that postoperative correction rate of valgus is acceptable at 5-14 degree range. (Bauer et al. 2005) In a study conducted by Levai et al., it was made clear that angle correction rate up to 5 degree result in long-term improvement of treatment results. (Levai et al. 2003) Advantages related to extreme correction of valgus angle has not yet studied. 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. Less correction of valgus angle is one of the treat fail risk factors stated in the study conducted by Causero et al. less correction of valgus leads to high fail risk of the treatment results. (Causero et al. 2002) Knees with ideal correction have less experienced treatment failure. According to the report of Rodriguez-Merchan et al, correcting varus deformity such that it reaches zero will lead to about 45% increase of the force imposed from body axis toward distal compartment and better treatment results will be obtained through shift of the force toward exterior part and decrease of pressure at the medial part. (Rodriguez-Merchan 2003) In a study conducted by Bove et al., correction rate up to 6 degree at tibiofemoral angle in the open wedge method had ideal treatment results. (Bove 2002) Similar to this and some other studies, correction rate of tibiofemoral angle was 5-8 degree in our study and treatment results during the six-month follow-up period indicate perfect results of the treatment. Adili et al. 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. (Adili et al. 2002)

### Conclusion

Generally, both surgical methods can be used to correct deformity. Modified open wedge method is preferred to classic open wedge one considering lack of intra articular fracture in this method since it can threat long-term prognosis of the surgery.

**Corresponding Author:** DR Seyed Hamid Barzegar, Department of Orthopedics, Tabriz University of medical sciences, Tabriz, Iran

[Dr.barzgar@yahoo.com](mailto:Dr.barzgar@yahoo.com)

### References

1. Adili A, Bhandari M, Giffin R, Whately C, Kwok DC. Valgus high tibial osteotomy. Comparison between an Ilizarov and a Coventry

- wedge technique for the treatment of medial compartment osteoarthritis of the knee. *Knee Surg Sports Traumatol Arthrosc* 2002;10:169-76.
2. Bauer T, Hardy P, Lemoine J, Finlayson DF, Tranier S, Lortat-Jacob A. Drop foot after high tibial osteotomy: a prospective study of aetiological factors. *Knee Surg Sports Traumatol Arthrosc* 2005;13:23-33.
  3. Bove JC. [Utilization of a porous alumina ceramic spacer in tibial valgus open-wedge osteotomy: fifty cases at 16 months mean follow-up]. *Rev Chir Orthop Reparatrice Appar Mot* 2002;88:480-485.
  4. Brosset T, Pasquier G, Migaud H, Gougeon F. Opening wedge high tibial osteotomy performed without filling the defect but with locking plate fixation (TomoFix) and early weight-bearing: prospective evaluation of bone union, precision and maintenance of correction in 51 cases. *Orthop Traumatol Surg Res* 2011;97:705-11.
  5. Causero A, Tcherkes-Zade T, Tcherkes-Zade D, Paschina E. The Ilizarov technique in the treatment of osteoarthritic genu varum. *Chir Organi Mov* 2002;87:235-40.
  6. Dejour H, Walch G, Deschamps G, Chambat P. [Arthrosis of the knee in chronic anterior laxity]. *Rev Chir Orthop Reparatrice Appar Mot* 1987;70-73:157;
  7. El-Assal MA, Khalifa YE, Abdel-Hamid MM, Said HG, Bakr HM. Opening-wedge high tibial osteotomy without bone graft. *Knee Surg Sports Traumatol Arthrosc* 2010;18:961-66.
  8. Gall N, Fickert S, Puhl W, Gunther KP, Stove J. [Predictors of tibial head transposition in the therapy of varus knee osteoarthritis]. *Z Orthop Ihre Grenzgeb* 2005;143:551-55.
  9. Gary J, Richards BS. Infantile tibia vara: correction of recurrent varus deformity following epiphyseolysis. *Orthopedics* 2008;31:503.
  10. Haviv B, Bronak S, Thein R, Kidron A, Thein R. Mid-term outcome of opening-wedge high tibial osteotomy for varus arthritic knees. *Orthopedics* 2012;35:e192-e196.
  11. Hinterwimmer S, von Eisenhart-Rothe R, Siebert M, Welsch F, Vogl T, Graichen H. Patella kinematics and patello-femoral contact areas in patients with genu varum and mild osteoarthritis. *Clin Biomech (Bristol, Avon)* 2004;19:704-10.
  12. Hutten D. [Surgery for femoro-tibial osteoarthritis of the knee]. *Rev Prat* 2009;59:1254-56.
  13. Johari AN, Dhawale AA, Salaskar A, Aroojis AJ. Congenital postero-medial bowing of the tibia and fibula: is early surgery worthwhile? *J Pediatr Orthop B* 2010;19:479-86.
  14. Keyhani S, Abbasian MR, Kazemi SM et al. Modified retro-tubercle opening-wedge versus conventional high tibial osteotomy. *Orthopedics* 2011;34:90;2011
  15. Kraal T, Mullender M, de Bruine JH et al. Resorbability of rigid beta-tricalcium phosphate wedges in open-wedge high tibial osteotomy: a retrospective radiological study. *Knee* 2008;15:201-5.
  16. Lee SC, Jung KA, Nam CH, Jung SH, Hwang SH. The short-term follow-up results of open wedge high tibial osteotomy with using an Aescula open wedge plate and an allogenic bone graft: the minimum 1-year follow-up results. *Clin Orthop Surg* 2010;2:47-54.
  17. Levai JP, Bringer O, Descamps S, Boisgard S. [Xenograft-related complications after filling valgus open wedge tibial osteotomy defects]. *Rev Chir Orthop Reparatrice Appar Mot* 2003;89:707-11.
  18. Madadi F, Eajazi A, Madadi F et al. Clinical results of reversed V-shaped high tibial corticotomy with minimally invasive surgery without internal fixation devices. *Orthopedics* 2010;33:388.
  19. Marmotti A, Castoldi F, Rossi R et al. Bone marrow-derived cell mobilization by G-CSF to enhance osseointegration of bone substitute in high tibial osteotomy. *Knee Surg Sports Traumatol Arthrosc* 2013;21:237-48.
  20. Merian M, Schafer D, Hintermann B. [Proximal tibial valgus osteotomy with callus distraction]. *Oper Orthop Traumatol* 2005;17:313-25.
  21. Ng YC, Sathappan SS, Wong HP. Management of knee osteoarthritis presenting with tibial stress fractures. *Singapore Med J* 2010;51:e149-e152.
  22. Niemeyer P, Schmal H, Hauschild O, von HJ, Sudkamp NP, Kostler W. Open-wedge osteotomy using an internal plate fixator in patients with medial-compartment gonarthrosis and varus malalignment: 3-year results with regard to preoperative arthroscopic and radiographic findings. *Arthroscopy* 2010;26:1607-16.
  23. Park YE, Song SH, Kwon HN, Refai MA, Park KW, Song HR. Gradual correction of idiopathic genu varum deformity using the Ilizarov technique. *Knee Surg Sports Traumatol Arthrosc* 2012.
  24. Pasquier P, Boutonnet M, Bourrilhon C, de Saint MG, Tourtier JP. Adrenaline infiltration in proximal tibial osteotomy: is there evidence for safety? *Arch Orthop Trauma Surg* 2012;132:575-76.
  25. Pei Z, Guan ZP, Zhang SL, Li YP, Zhang Z. [Autogenous bone graft in the treatment of total

- knee arthroplasty for severe genu varus with tibial plateau bone defect]. *Beijing Da Xue Xue Bao* 2011;43:707-13.
26. Ribeiro CH, Severino NR, Cury RP et al. A new fixation material for open-wedge tibial osteotomy for genu varum. *Knee* 2009;16:366-70.
  27. Rodriguez-Merchan EC. Management of musculoskeletal complications of hemophilia. *Semin Thromb Hemost* 2003;29:87-96.
  28. Saragaglia D, Blaysat M, Mercier N, Grimaldi M. Results of forty two computer-assisted double level osteotomies for severe genu varum deformity. *Int Orthop* 2012;36:999-1003.
  29. Saragaglia D, Mercier N, Colle PE. Computer-assisted osteotomies for genu varum deformity: which osteotomy for which varus? *Int Orthop* 2010;34:185-90.
  30. Saragaglia D, Nemer C, Colle PE. Computer-assisted double level osteotomy for severe genu varum. *Sports Med Arthrosc* 2008;16:91-96.
  31. Saragaglia D, Roberts J. Navigated osteotomies around the knee in 170 patients with osteoarthritis secondary to genu varum. *Orthopedics* 2005;28:s1269-s1274.
  32. Schiedel F, Probst A, Buller TC, Rodl R. The postoperative patella height: a comparison of additive and subtractive high tibial osteotomy in correcting the genu varum. *Arch Orthop Trauma Surg* 2009;129:1271-77.
  33. Schroter S, Gonser CE, Konstantinidis L, Helwig P, Albrecht D. High complication rate after biplanar open wedge high tibial osteotomy stabilized with a new spacer plate (Position HTO plate) without bone substitute. *Arthroscopy* 2011;27:644-52.
  34. Shiha A, El-Deen MA, Khalifa AR, Kenawey M. Ilizarov gradual correction of genu varum deformity in adults. *Acta Orthop Belg* 2009;75:784-91.
  35. Shim JS, Lee SH, Jung HJ, Lee HI. High tibial open wedge osteotomy below the tibial tubercle: 36. clinical and radiographic results. *Knee Surg Sports Traumatol Arthrosc* 2013;63-21:57;
  36. Sim JA, Kwak JH, Yang SH, Choi ES, Lee BK. Effect of weight-bearing on the alignment after open wedge high tibial osteotomy. *Knee Surg Sports Traumatol Arthrosc* 2010;18:874-78.
  37. Staubli AE, Jacob HA. Evolution of open-wedge high-tibial osteotomy :experience with a special angular stable device for internal fixation without interposition material. *Int Orthop* 2010;34:167-72.
  38. Stevens PM, Novais EN. Multilevel guided growth for hip and knee varus secondary to chondrodysplasia. *J Pediatr Orthop* 2012;33:2:626
  39. Wu H, Xu Q, Zhou W. [Arthroscopic evaluation and treatment of the disorder resulted from open meniscectomy of the knee]. *Zhonghua Wai Ke Za Zhi* 1995;33:586-88.
  40. Zhang AL, Exner GU, Wenger DR. Progressive genu valgum resulting from idiopathic lateral distal femoral physeal growth suppression in adolescents. *J Pediatr Orthop* 2008;28:752-56.
  41. Zhang HN, Leng P, Wang YZ, Lu CY, Wang XD, Wang CY. [The efficacy of open-wedge high tibial osteotomy for varus knee]. *Zhonghua Wai Ke Za Zhi* 2010;48:368-71.
  42. Zhang HN, Zhang J, Lv CY et al. Modified biplanar open-wedge high tibial osteotomy with rigid locking plate to treat varus knee. *J Zhejiang Univ Sci B* 2009;10:689-95.

9/26/2013