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Changes in patellar height and tibia inclination angle following open-wedge high tibial osteotomy

Açık kama yüksek tibia osteotomisi sonrasında patella yüksekliği ve tibial eğim açısındaki değişiklikler

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Amaç: Açık kama yüksek tibial osteotomiden sonra patella yüksekliği ve tibial eğim açısında görülen değişiklikler ve bunların hasta memnuniyeti ile ilişkisi incelendi.

Çalışma planı: Medial gonartroz nedeniyle 16 hastanın (4 erkek, 12 kadın; ort. yaş 55; dağılım 44-66) 18 dizine otojen kemik grefti ve medial plakla açık kama tipi proksimal tibial osteotomi yapıldı. Ahlbäck sınıflamasına göre, dokuz dizde (%50) derece I, sekiz dizde (%44.4) derece II, bir dizde (%5.6) derece III osteoartrit vardı. Ameliyat öncesi ve sonrasında Bauer yöntemiyle femorotibial açı, Harvey-Moore yöntemiyle tibial plato eğim açısı, Blackburne-Peel yöntemiyle patellar yükseklik belirlendi. Klinik değerlendirmede Lysholm-Gillquist skoru kullanıldı. Son kontrollerde hastaların tedaviden memnuniyet düzeyleri 10 puanlık skala ile sorgulandı. Ortalama takip süresi 54.2 ay (dağılım 25-96 ay) idi.

Sonuçlar: Ameliyat sonrasında femorotibial açıda ortalama 13.6° düzeltme sağlandı (p<0.05), tibial plato eğim açısında ortalama artış 2.9° idi (p<0.05). Patellar yükseklikte 15 dizde (%83.3) ortalama %15 azalma görüldü (p<0.05). Ameliyat öncesinde ortalama 61 olan Lysholm-Gillquist skoru son kontrolde 86'ya yükseldi (p<0.05). On bir dizde (%61.1) mükemmel, altı dizde (%33.3) iyi, bir dizde (%5.6) kötü sonuç alındı. Hasta memnuniyet skoru ortalaması 8.1 (dağılım 5-10) bulundu. Femorotibial açıdaki ve Lysholm-Gillquist skorundaki değişimler hasta memnuniyeti skoru ile anlamlı ilişki gösterdi (p<0.05). Birer hastada sırasıyla kaynamama, ameliyat sırasında eklem içi kırık ve yüzeyel yara enfeksiyonu görüldü.

Çıkarımlar: Açık kama osteotomisi sonrasında tibial eğim açısı ve patellar yükseklik değerlerindeki değişiklikler kısa dönem hasta memnuniyetini olumsuz etkilememektedir.

Anahtar sözcükler: Diz eklemi; osteoartrit, diz/cerrahi; osteotomi/yöntem; patella/radyografi; hasta memnuniyeti; tibia/cerrahi.

Objectives: We investigated changes in patellar height and tibial inclination angle after open-wedge high tibial osteotomy and the effect of these changes on patient satisfaction.

Methods: The study included 18 knees of 16 patients (4 males, 12 females; mean age 55 years; range 44 to 66 years) who underwent open-wedge proximal tibial osteotomy with autogenous bone graft and medial plate for medial compartment gonarthrosis. Nine knees (50%) had Ahlbäck grade I, eight knees (44.4%) had grade II, and one knee (5.6%) had grade III osteoarthritis. Pre- and postoperatively, femorotibial angle, tibial inclination angle, and patellar height were measured according to the Bauer, Harvey-Moore, and Blackburne-Peel methods, respectively. Clinical evaluations were made using the Lysholm-Gillquist score. Patient satisfaction was questioned with a 10-point scale. The mean follow-up was 54.2 months (range 25 to 96 months).

Results: Postoperatively, the mean correction of the femorotibial angle was 13.6° (p<0.05), and the mean increase in the tibial inclination angle was 2.9° (p<0.05). Fifteen knees (83.3%) exhibited a significant decrease in patellar height by a mean of 15% (p<0.05). The mean Lysholm-Gillquist score increased from preoperative 61 to 86 at the latest follow-up (p<0.05). The results were excellent in 11 knees (61.1%), good in six knees (33.3), and poor in one knee (5.6%). The mean patient satisfaction score was 8.1 (range 5 to 10). Changes in the femorotibial angle and Lysholm-Gillquist score were significantly correlated with patient satisfaction (p<0.05). Three patients had nonunion, perioperative intra-articular fracture, and superficial wound infection, respectively.

Conclusion: Changes in the tibial inclination angle and patellar height following open-wedge tibial osteotomy do not have an adverse effect on short-term patient satisfaction.

Key words: Knee joint; osteoarthritis, knee/surgery; osteotomy/methods; patella/radiography; patient satisfaction; tibia/surgery.

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The goal of high tibial osteotomy HTO for medial compartment gonarthrosis is to transfer the load to the healthy lateral compartment.[1,2] Besides closing-wedge osteotomy, dome osteotomy and opening-wedge osteotomy methods, opening and closing-wedge tibial osteotomy with hemicallotasis method has been described.[2-9]

Several studies which report development of anatomical changes in patellar tendon and the proximal tibia following HTO have been published recently.[10-13] Technical problems in total knee arthroplasty after HTO in the following years have also been reported. [1,14,15] However, there are no studies in the literature evaluating the effect of these anatomical changes on clinical and functional results, to our knowledge.

The changes in tibial plateau inclination angle, femorotibial angle and patellar tendon length following open wedge HTO for medial gonarthrosis of the knee have been measured in this study. The correlation of the observed changes and postoperative patient satisfaction have been evaluated.

Patients and method

Between November 1998 and May 2005, open wedge HTO using autogenous iliac bone graft and medial plate for medial compartment gonarthrosis were performed in 33 knees of 30 patients. Of these 30 patients, 18 knees of 16 patients with at least two years of follow-up (4 man, 12 woman; median age 55; range 44-66) were evaluated.

Patients included in this study had a history of failed conservative treatment for 3 months, had pain limited to medial compartment only, with range of motion more than 120 degrees in the affected knee, had intraarticular narrowing less than %50 in weight-bearing knee radiographs and had varus deformity only limited to tibia. The contraindications of the surgery were : loss of extension more than 5 degrees, medial instability more than 5mm., presence of romatoid arthritis, poor general status of the patient and generalised osteoarthritis of the knee in weight bearing A-P radiographs.

The etiology was found to be idiopathic in 16 knees of 14 patients, and posttraumatic in one patient. One patient had a history of previous meniscectomy surgery. Nine knees (50%) had Ahlbäck grade I, eight knees (44.4%) had grade II, and one knee (5.6%) had grade III osteoarthritis.

Passive and active range of motion (ROM) exercises were begun on the second postoperative day; partial weight bearing with crutches was encouraged on the sixth and full weight bearing on the 10th postoperative week.

Weight-bearing anteroposterior (A-P), lateral and axial knee radiographs were taken pre-operatively and on sixth and tenth week, first year and at last assessment post-operatively. On the sixth and tenth postoperative week, the bone healing of the osteotomy site was evaluated radiographically, and range of motion of the knees were recorded.

The femorotibial angles of the knees were evaluated on the preoperative A-P weight-bearing radiographs using the method of Bauer; a postoperative angle of 168-172 degrees was planned.[17] The femorotibial angles were evaluated at the radiograhs taken at the first postoperative day, at the sixth and tenth postoperative weeks, at one year and at the last assessment. Tibial inclination angles were evaluated preoperatively and postoperatively using the Harvey-Moore method. (Figure 1) [18] Patellar height was evaluated using the Blackburne-Peel method at the preoperative and last assessment lateral knee radiographs taken at 30 degrees of flexion. (Figure 2) [19] Clinical functional results were evaluated according to the Lysholm- Gillquist score preoperatively and at the last assessment: 85 point or higher was accepted as perfect, 70-85 points as good, 70 points or less was accepted as poor result. [20] Patient satisfaction was evaluated subjectively by the patients using the method described by Miller et al [21] (1=not satisfied, 10= very satisfied). The average follow up was 54.2 months (range 25 to 96 months).

Statistical analyzes were performed using the SPSS 11.5 programme. The data was given as mean values and in percentages. Postoperative femorotibial angle, tibia inclination angle, patellar height and changes in Lysholm- Gillquist scores were compared using the Wilcoxon signed-rank test. The correlation between three indexes and clinical results was determined using Spearman's nonparametric analysis. The P-values less then 0.05 ($P<0.05$) were the level of significance.

Results

Fifteen of the 18 osteotomies healed in 10 weeks and 2 osteotomies healed in 18 weeks. Nonunion was observed in one patient. The average consolidation time was 7.1 months (range 6 to 9 months). No statistically

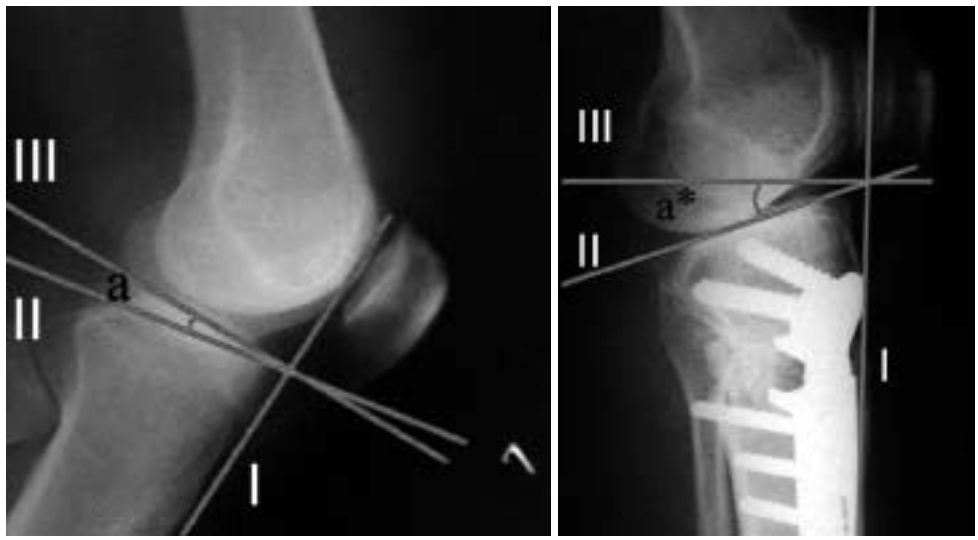

Figure 1. Measurement of tibial plateau inclination angle using Harvey-Moore method. I: A line tangential to the anterior tibial crest in the lateral plane is drawn; II: Another line tangential to the joint facet of tibia is drawn.; III: A line perpendicular to the first line; a: Tibial inclination angle.

significant change in the range of motions of the operated knees was observed (preoperative 128°, range 120° to 135°; at the last assessment 127°, range 120° to 135°). (P<0.05). The average femorotibial angle measured on weight-bearing A-P radiographs at the preoperative and at the 10th postoperative week were 183.2° (range 179° to 192) and 169.6° (range 166° to 172°), respectively (p< 0,05); the mean achieved correction was 13.6° (range 7° to 23°). In 16 of the 18 knees, a femorotibial angle of 168-172 degrees was obtained in the 10th postoperative week. A femorotibial angle more than 172 degrees (undercorrection) was not observed in any of the patients. A femorotibial angle less than 168 degrees (overcorrection) was observed in two patients. Loss of reduction more than 2 degrees was not observed in any of the patients in the follow up. The preoperative tibial inclination angle according to the Harvey-Moore method of 7.2 degrees (range 6 to 9) changed to 10.1 degrees (range 8°to 11°) postoperatively. (p<0.05). The average increase in tibia inclination angle was 2.9 degrees. Fifteen knees (83.3%) exhibited a significant decrease in patellar height by a mean of 15% (p<0.05). The preoperative and postoperative Blackburne-Peel ratio were 0.98, and 0.83, respectively (p<0.05). The average shortening of the patellar tendon in this study was %15 (range %0 to %20)

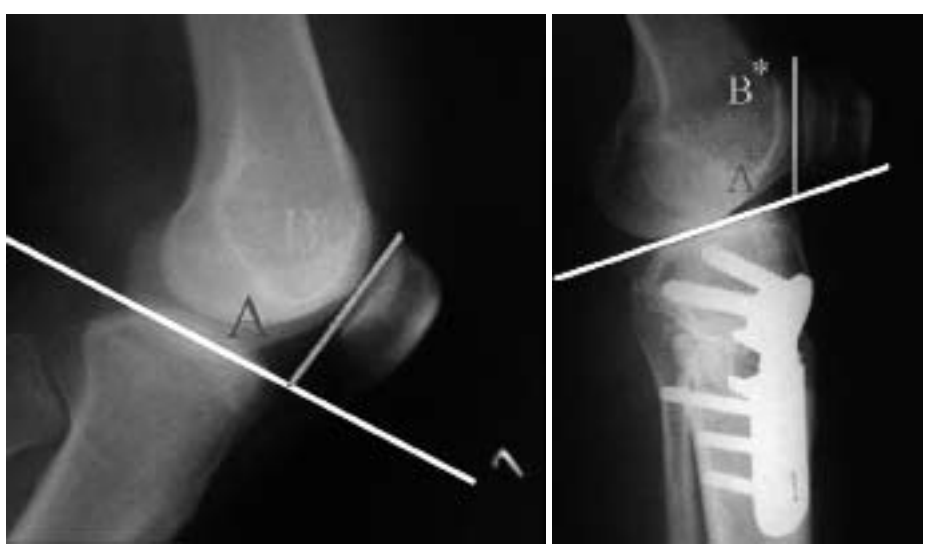

Figure 2. Measurement of patellar tendon height using Blackburne-Peel method.
A: Distance from proximal pole to the tangential line of the joint line; B: Length of patellar facet.

The mean Lysholm-Gillquist score increased from preoperative 61 (range 45-to 77) to 86 (range 69 to 96) at the latest follow-up ($p<0.05$). The functional results were perfect in 11 (%61.1) knees, good in 6 (%33.3) knees and poor in 1 (%5.6) knee. Subjective evaluation of the patients revealed an average of 8.1 (range 5 to 10) patient satisfaction score. Statistically significant correlation between the femorotibial angle and Lysholm-Gillquist score with patient satisfaction score was observed. (for both criteria, $r=0.603$, $p<0.05$) A negative corelation was observed between the tibial plateau inclination angle and patient satisfaction score. ($r=-0.756$). No statistically significant correlation was found between the change in patellar tendon height and patient satisfaction score ($r=0.296$, $p>0.05$). The only nonunion observed in the series was later managed succesfully with a circular external fixator and autogenous iliac bone graft. The osteotomy healed in the12th postoperative week after the secondary procedure. The tibial inclination angle of the patient was measured as 11°, the decrease in the patellar tendon length as %0, the Lysholm-Gillquist score as 69 and the patient satisfaction score as 5.

Intraarticular fracture was observed in one patient and was managed conservatively with cast brace for 10 weeks. The tibial inclination angle of this patient was measured as 10°, the decrease in the patellar tendon height as %16, the Lysholm-Gillquist score as 75 and the patient satisfaction score as 6 at the last assessment. Both of these patients were excluded from the statistical evaluation because of negative effect of complications on patient satisfaction scores.

Superficial wound infection was observed in one patient and was manged with local wound care and parenteral antibiotic therapy. The tibial inclination angle of this patient was measured as 11°, the decrease in the patellar tendon height as %17, the Lysholm-Gillquist score as 79 and the patient satisfaction score as 8 at the last assessment. Peroneal nerve palsy, compartment syndrome, intraarticular migration of the osteosynthesis materials, deep venous thrombosis and deep infection were not observed in this study.

Discussion

Eighty to ninety percent of survival rates for high tibial osteotomy for the first five postoperative years are reported, however, this high survival rates have been reported to drop in the following years. [1,22,23] Clinical results are reported to be related to the postoperative time, age of the patient, the amount of preoperative varus deformity, preoperative knee flexion, body weight, history of previous menissectomy, the amount of postoperative axial corrrection and presence of lateral tibial migration.[1,23-26] A slight postoperative overcorrection was suggested for good long term functional results.[2,5,12] Hernigou et al.[5] reported that knees with 3°-6° postoperative valgus had very good functional results with improvement in medial compartment gonarthrosis, however, they have also observed that the functional results worsened if the knees had less than 3 degrees of valgus. Coventry et al [2] reported that only %63 of satisfactory results would be expected in knees with neutral or varus mechanical axis, but satisfactory results would increase up to %94 if the knees were 4°to 6° valgus. A postoperative angle of 168°-172° was planned in this study. None of the patients had undercorrection and no statistically significant correlation was observed with the overcorrection observed in two patients and the functional results.

Several studies which evaluates the effect of HTO on tibial inclination angle have noticed the importance of tibial inclination angle on knee stability.[27-29] Kaper et al [30] concluded that an increase in tibial inclination angle would result in posterior translation of femur on tibia. An increase of 10 degrees in the angle would cause a 6 mm of tibial translation, which would also cause an increase in severity of arthrosis compromising the future total knee arthroplasty operations by causing a tibial bone defect.[27] The average amount of increase in tibial inclination was 2.9° in this study. Scuderi et al [10] found a postoperative decrease in tibial inclination in %89 of their patients following HTO. Tigani et al [31] reported they had observed more shortening of patellar tendon in patients with open-wedge HTO compared to patients with closing-wedge HTO. Kesmezacar et al [32] found an average loss of %9.1 of the patellar height in their series. Wright et al [33] reported a loss of %28 of patellar height in patients who had undergone open-wedge HTO and concluded that it would later cause patellofemoral problems and technical problems in future total knee arthroplasty operations. A %15 of shortening in the patellar tendon was observed in this study. Patellofemoral pain was not observed.

We also think that shortening of the patellar tendon may compromise our future total knee arthroplasty operations.

Nonunion was reported in %0-4.7 in several studies.[1,34] Miniaci et al [35] concluded that an intact lateral cortex would both increase the stability of the osteotomy and decrease the rate of nonunion. Hernigou et al [5] observed intraoperative fracture of the lateral cortex in %22.5 of the patients, but they reported that displacement of the fragments was observed only in half of these patients. Nonunion was observed in only one (%5.6) patient in this study. Re-evaluation of the radiographs of this patient revealed an iatrogenic intraoperative fracture of the lateral cortex which would be responsible of instability and nonunion.

Use of distractors and an osteotomy close to the joint line were thought to be responsible for intrarticular fracture of the lateral tibial plateau.[6] The incidence of intrarticular fracture was reported as %5-14.6 in several studies.[7,36] Esenkaya [6] reported a %7.5 of intrarticular fracture in 40 patients, and Bombacı et al [11] reported a %4.5 in their series of 22 patients. One patient with an intrarticular fracture had a poor functional result at the last assessment in this study.

Billings et al [37] emphasized the importance of wide soft tissue dissection on risk of deep infection. Tokgozoglu et al [38] reported five pin track infections, one septic arthritis, one subacut osteomyelitis in 16 patients managed with Charnley type external fixator. No deep infection was observed in this study. One patient with superficial wound infection healed with local wound care and parenteral antibiotics.

Following open-wedge HTO, use of autogenous iliac bone graft or bone substitutes had been proposed. [5,6,36] Spahn [36] reported that bone grafting would be unnecessary in corrections less than 12 degrees. Esenkaya [6] reported that he had used both bicortical and tricortical autogenous iliac bone graft as well as allografts, but that he lately preferred bicortical grafts. Autogenous iliac bone graft was used in all patients in this study. Although postoperative pain was observed in the donor graft site, it resolved spontaneously in the following few days. Hematoma or infection at the donor site was not observed.

Sprenger and Doerzbacher[39] concluded that peroneal nevre palsy was the main reason for patient dissatisfaction in the long term following HTO. The main advantage of open-wedge HTO is that fibular osteotomy is unnecessary with no risk of fibular paralysis.[5,40,41] Hernigou et al [5] reported only one temporary paralysis of peroneal nerve which resolved spontaneously in their series of 93 patients who had undergone open-wedge HTO. Peroneal nerve injury was not observed in this study.

Total knee arthroplasty might be necessary after HTO. Vainionpaa et al [42] reported 16 (%15.5) of the 103 patients who had undergone HTO needed a total knee arthroplasty procedure in an average of 7.6 years. In Kaper et al [30] study, %23.9 of the patients needed a TKA. None of the five patients with the longest follow up (range 70-96 months) needed a TKA in this study.

In conclusion, we have observed a shortening of patellar tendon following open-wedge HTO in this study; however, no statistically significant effect of this anatomical change on patient satisfaction scores was found. An increase in tibial inclination angle following open-wedge HTO was also observed and this increase had a negative effect on patient satisfaction. A statistically significant correlation was found between the Lysholm-Gillquist scores and patient satisfaction scores. Although we have not performed any TKA in our patients, we believe that patellar tendon shortening may cause technical problems in the future arthroplasty operations.

References

1. Insall JN, Joseph DM, Msika C. High tibial osteotomy for varus gonarthrosis. A long-term follow-up study. J Bone Joint Surg [Am] 1984;66:1040-8.
2. Coventry MB, Ilstrup DM, Wallrichs SL. Proximal tibial osteotomy. A critical long-term study of eighty-seven cases. J Bone Joint Surg [Am] 1993;75:196-201.
3. Yercan HS, Okcu G, Aydoğdu S, Oziç U. Clinical results of lateral closing wedge high tibial osteotomy for osteoarthritis of the knee (Oblique osteotomy with tension band fixation). [Article in Turkish] Acta Orthop Traumatol Turc 2004;38:89-95.
4. Maquet P. Valgus osteotomy for osteoarthritis of the knee. Clin Orthop Relat Res 1976;(120):143-8.
5. Hernigou P, Medevielle D, Debeyre J, Goutallier D. Proximal tibial osteotomy for osteoarthritis with varus defor-

mity. A ten to thirteen-year follow-up study. J Bone Joint Surg [Am] 1987;69:332-54.
6. Esenkaya I. Fixation of proximal tibia medial opening wedge osteotomy using plates with wedges. [Article in Turkish] Acta Orthop Traumatol Turc 2005;39:211-23.
7. Kılıç B. Varus gonartrozunda puddu plağı ile yüksek tibia osteotomisi [Uzmanlık Tezi]. İstanbul: İstanbul Üniversitesi İstanbul Tıp Fakültesi; 2004.
8. Nakamura E, Mizuta H, Kudo S, Takagi K, Sakamoto K. Open-wedge osteotomy of the proximal tibia hemicallotasis. J Bone Joint Surg [Br] 2001;83:1111-5.
9. Nagi ON, Kumar S, Aggarwal S. Combined lateral closing and medial opening-wedge high tibial osteotomy. J Bone Joint Surg [Am] 2007;89:542-9.
10. Scuderi GR, Windsor RE, Insall JN. Observations on patellar height after proximal tibial osteotomy. J Bone Joint Surg [Am] 1989;71:245-8.
11. Bombaci H, Canbora K, Onur G, Görgeç M. The effect of open wedge osteotomy on the posterior tibial slope. [Article in Turkish] Acta Orthop Traumatol Turc 2005;39:404-10.
12. Orsel S, Altun M, Bekmezci T, Tonbul M, Yalaman O. Early results of medial opening wedge osteotomy in varus gonarthrosis. [Article in Turkish] Acta Orthop Traumatol Turc 2006;40:193-8.
13. Westrich GH, Peters LE, Haas SB, Buly RL, Windsor RE. Patella height after high tibial osteotomy with internal fixation and early motion. Clin Orthop Relat Res 1998;(354):169-74.
14. Closkey RF, Windsor RE. Alterations in the patella after a high tibial or distal femoral osteotomy. Clin Orthop Relat Res 2001;(389):51-6.
15. Meding JB, Keating EM, Ritter MA, Faris PM. Total knee arthroplasty after high tibial osteotomy. A comparison study in patients who had bilateral total knee replacement. J Bone Joint Surg [Am] 2000;82:1252-9.
16. Ahlback S. Osteoarthrosis of the knee. A radiographic investigation. Acta Radiol Diagn 1968;Suppl 277:7-72.
17. Bauer GC, Insall J, Koshino T. Tibial osteotomy in gonarthrosis (osteo-arthritis of the knee). J Bone Joint Surg [Am] 1969;51:1545-63.
18. Moore TM, Harvey JP Jr. Roentgenographic measurement of tibial-plateau depression due to fracture. J Bone Joint Surg [Am] 1974;56:155-60.
19. Blackburne JS, Peel TE. A new method of measuring patellar height. J Bone Joint Surg [Br] 1977;59:241-2.
20. Lysholm J, Gillquist J. Evaluation of knee ligament surgery results with special emphasis on use of a scoring scale. Am J Sports Med 1982;10:150-4.
21. Miller BS, Joseph TA, Barry EM, Rich VJ, Sterett WI. Patient satisfaction after medial opening high tibial osteotomy and microfracture. J Knee Surg 2007;20:129-33.
22. Rinonapoli E, Mancini GB, Corvaglia A, Musiello S. Tibial osteotomy for varus gonarthrosis. A 10- to 21-year follow-up study. Clin Orthop Relat Res 1998;(353):185-93.
23. Naudie D, Bourne RB, Rorabeck CH, Bourne TJ. The Install Award. Survivorship of the high tibial valgus osteotomy. A 10- to -22-year follow-up study. Clin Orthop Relat Res 1999;(367):18-27.
24. Noyes FR, Barber SD, Simon R. High tibial osteotomy and ligament reconstruction in varus angulated, anterior cruciate ligament-deficient knees. A two- to seven-year follow-up study. Am J Sports Med 1993;21:2-12.
25. Dugdale TW, Noyes FR, Styer D. Preoperative planning for high tibial osteotomy. The effect of lateral tibiofemoral separation and tibiofemoral length. Clin Orthop Relat Res 1992;(274):248-64.
26. Terauchi M, Shirakura K, Kobuna Y, Fukasawa N. Axial parameters affecting lower limb alignment after high tibial osteotomy. Clin Orthop Relat Res 1995;(317):141-9.
27. Dejour H, Bonnin M. Tibial translation after anterior cruciate ligament rupture. Two radiological tests compared. J Bone Joint Surg [Br] 1994;76:745-9.
28. Giffin JR, Vogrin TM, Zantop T, Woo SL, Harner CD. Effects of increasing tibial slope on the biomechanics of the knee. Am J Sports Med 2004;32:376-82.
29. Cullu E, Aydogdu S, Alparslan B, Sur H. Tibial slope changes following dome-type high tibial osteotomy. Knee Surg Sports Traumatol Arthrosc 2005;13:38-43.
30. Kaper BP, Bourne RB, Rorabeck CH, Macdonald SJ. Patellar infera after high tibial osteotomy. J Arthroplasty 2001; 16:168-73.
31. Tigani D, Ferrari D, Trentani P, Barbanti-Brodano G, Trentani F. Patellar height after high tibial osteotomy. Int Orthop 2001;24:331-4.
32. Kesmezacar H, Erginer R, Ogut T, Seyahi A, Babacan M, Tenekecioglu Y. Evaluation of patellar height and measurement methods after valgus high tibial osteotomy. Knee Surg Sports Traumatol Arthrosc 2005;13:539-44.
33. Wright JM, Heavrin B, Begg M, Sakyrd G, Sterett W. Observations on patellar height following opening wedge proximal tibial osteotomy. Am J Knee Surg 2001;14:163-73.
34. Brouwer RW, Jakma TS, Bierma-Zeinstra SM, Verhagen AP, Verhaar J. Osteotomy for treating knee osteoarthritis. Cochrane Database Syst Rev 2005;1:CD004019.
35. Miniaci A, Ballmer FT, Ballmer PM, Jakob RP. Proximal tibial osteotomy. A new fixation device. Clin Orthop Relat Res 1989;(246):250-9.
36. Spahn G. Complications in high tibial (medial opening wedge) osteotomy. Arch Orthop Trauma Surg 2004;124:649-53.
37. Billings A, Scott DF, Camargo MP, Hofmann AA. High tibial osteotomy with a calibrated osteotomy guide, rigid internal fixation, and early motion. Long-term follow-up. J Bone Joint Surg [Am] 2000;82:70-9.
38. Tokgözoğlu M, Acaroğlu E, Alpaslan AM. Gonartroz tedavisinde yüksek tibial osteotominin yeri. Ortopedi Travmatoloji Rehabilitasyon Dergisi 1988;3:152-8.
39. Sprenger TR, Doerzbacher JF. Tibial osteotomy for the treatment of varus gonarthrosis. Survival and failure anal-

ysis to twenty-two years. J Bone Joint Surg [Am] 2003;85: 469-74.

40. Franco V, Cerullo G, Cipolla M, Gianni E, Puddu G. Open wedge high tibial osteotomy. Techniques in Knee Surgery 2002;1:43-53.
41. Magyar G, Toksvig-Larsen S, Lindstrand A. Open wedge tibial osteotomy by callus distraction in gonarthrosis. Operative technique and early results in 36 patients. Acta Orthop Scand 1998;69:147-51.
42. Vainionpaa S, Laike E, Kirves P, Tiusanen P. Tibial osteotomy for osteoarthritis of the knee. A five to ten-year follow-up study. J Bone Joint Surg [Am] 1981;63: 938-46.