Eklem Hastalıkları ve Cerrahisi
Joint Diseases and Related Surgery

Original Article / *Çalışma - Araştırma*

Eklem Hastalık Cerrahisi
2012;23(2):82-87

Radiological analysis of closed-wedge high tibial osteotomy

Kapalı kama yüksek tibial osteotomisinin radyolojik analizi

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Objectives: In this study, we aimed to evaluate changes in frontal plane (anatomical axis) and sagittal plane (tibial slope, patellar height) parameters following closed-wedge high tibial osteotomy (HTO) and possible correlations between them.

Patients and methods: Between June 2003 and May 2007, 15 knees of the 13 female patients (mean age 52.6 years; range 45 to 64 years) who were followed on a regular basis in our outpatient clinic and underwent closed-wedge HTO were included. The mean follow-up was 49 months (range 29-75 months). Radiologic analysis was performed using pre- and postoperative anatomical axis, tibial slope, and patellar height measurements [Caton index (CI) and Insall-Salvati index (ISI)]. The findings were analyzed by using Wilcoxon matched pairs test and Pearson's correlation test.

Results: Preoperative varus deformity was 6.3°±2.7°, while it was measured as 7.2°±2.5° valgus in the last visit (p=0.0004). The pre- and postoperative CI were 0.97±0.1 and 0.96±0.1, respectively (p=0.85). The ISI decreased from 1.23±0.15 to 1.14±0.15 (p=0.012). Patella baja was observed in only one patient (ISI=0.77). Preoperatively tibial slope was 6.5°±2.4°, while it was measured as 0.06°±3.4° in the last visit (p=0.0001). There was no correlation between frontal plane angle change and tibial slope, also between patellar height and tibial slope.

Conclusion: Closed-wedge HTO does not result in significant changes in patellar height. The risk of patella baja can be decreased through minimal dissection around patellar tendon. However, closed-wedge HTO reduces tibial slope significantly. Optimal resection from posterior tibia is necessary to prevent this condition. A possible loss of tibial slope should be considered in the further reconstructive procedures.

Key words: Closed-wedge; gonarthrosis; high tibial osteotomy; patellar height; tibial slope.

Amaç: Kapalı kama yüksek tibial osteotomi (YTO) uygulamaları sonrası frontal plan (anatomik aks) ve sagital plan (tibial eğim, patellar yükseklik) parametrelerindeki değişim ile bu değişimler arasındaki muhtemel ilişkiler değerlendirildi.

Hastalar ve yöntemler: Haziran 2003 - Mayıs 2007 tarihleri arasında kliniğimizde düzenli izlemi yapılan, kapalı kama YTO uygulanmış 13 kadın hastanın (ort. yaşı 52.6 yıl; dağılım 45-64 yıl) 15 dizi çalışmaya dahil edildi. Ortalama izlem süresi 49 ay (dağılım 29-75 ay) idi. Radyolojik değerlendirme için ameliyat öncesi ve sonrası anatomik aks, tibial eğim ve patellar yükseklik ölçümleri [Caton indeksi (Cİ) ve Insall-Salvati indeksi (İSİ)] yapıldı. Sonuçlar Wilcoxon eşleştirilmiş iki örnek testi ve Pearson korelasyon testi ile değerlendirildi.

Bulgular: Ameliyat öncesi 6.3°±2.7° varus deformitesi, son kontrolde 7.2°±2.5° valgus olarak ölçüldü (p=0.0004). Ameliyat öncesi ve sonrası Cİ sırasıyla 0.97±0.1 ve 0.96±0.1 idi (p=0.85). Insall-Salvati indeksi ise 1.23±0.15'ten 1.14±0.15'e düştü (p=0.012). Yalnızca bir olguda patella baja saptandı (İSİ=0.77). Ameliyat öncesi 6.5°±2.4° olan tibial eğim, son kontrolde 0.06°±3.4° olarak ölçüldü (p=0.0001). Frontal plan açı değişimi ile tibial eğim arasında ve patellar yükseklik ile tibial eğim arasında herhangi bir korelasyon saptanmadı.

Sonuç: Kapalı kama YTO, patellar tendon yüksekliğinde belirgin değişime neden olmaz. Patellar tendon çevresinde aşırı diseksiyon yapılmaması ile patella baja riski azaltılabilir. Ancak kapalı kama YTO, tibial eğimi belirgin olarak azaltır. Bu durumun önlenmesi için posteriyor tibiadan rezeksiyonun yeterli yapılması gereklidir. Olası bir eğim kaybı, ilerideki rekonstrüktif işlemler sırasında göz önünde bulundurulmalıdır.

Anahtar sözcükler: Kapalı kama; gonartroz; yüksek tibial osteotomi; patellar yükseklik; tibial eğim.

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- *Presented at the XXI. Turkish National Congress of Orthopaedics and Traumatology, November 3-8, 2009, Çeşme, Turkey.*

The aims of high tibial osteotomy (HTO) are to decrease pain, to correct the deformity, to increase functional capacity and to postpone total knee arthroplasty.[1-3] High tibial osteotomy can be carried out by open or closed wedge techniques. There is no consensus in the literature on which technique is superior due to many advantages and disadvantages of both.[4]

There is current interest in the importance of changes in sagittal plane parameters such as patellar height and tibial slope, and some researchers have tried to correlate between frontal and sagittal plane values. Furthermore, the long-term follow-up effect of changes in tibial slope on the loads of the cruciates not clearly known.[5,6]

In this study we aimed to evaluate and analyse the correlations of the radiological parameters of anatomical axis, tibial slope and patellar height after HTO.

PATIENTS AND METHODS

We retrospectively evaluated the cases treated via closed HTO between June 2003 and May 2007. Inclusion criteria were medial compartment gonarthrosis with varus malalignment, no benefit of conservative intervention for at least six months, and no manifest arthritic findings in the lateral compartment (Figure 1, 2). Exclusion criteria included range of motion (ROM) less than 90°, inflammatory arthritis, posttraumatic arthrosis, and follow-up less than 12 months. This study comprised 15 knees of 13 female patients (mean age 52.6 years; range 45 to 64 years) after these exclusions. The mean follow-up was 49 months (range 29-75) (Figure 3, 4).

All operations were carried out under spinal anesthesia using pneumatic tourniquet. The superior tibiofibular joint capsule was incised and released instead of fibular osteotomy. After exposing the lateral tibial cortex, closed wedge high tibial osteotomy was carried out under C arm fluoroscopy. More attention was given to minimal dissection carried out around the patellar tendon. Achievement of a postoperative anatomic axis of 10°-12° valgus was aimed for, and a cylindrical long leg cast was applied from ankle to groin.

Antibiotic and venous thromboembolism prophylaxis were maintained for 24 hours and 14 days respectively. On the second postoperative day the patients were encouraged to weight bear as tolerated after removing suction drains. In addition isometric exercises were instructed, and the patients were discharged from hospital.

On the sixth postoperative week, cylindrical casts were removed after X-ray control by observing healing tissue in the osteotomy site. Patients were advised to use functional knee braces to feel more confidence. Full weight-bearing was started with or without crutches.

Radiological evaluation

Standing X-rays were obtained from all cases pre- and postoperatively. The anatomical axis was measured on anteroposterior X-rays. The posterior tibial slope and patellar height were measured on lateral X-rays. The posterior tibial slope was measured while taking the

Figure 1. Preoperative anteroposterior X-ray.

Figure 2. Preoperative lateral X-ray.

Figure 3. Postoperative 55 months anteroposterior X-ray.

Figure 4. Postoperative 55 months lateral X-ray.

reference point of posterior tibial cortex as described by Brazier et al.[7] (Figure 5a). The Caton index (CI) and Insall-Salvati index (ISI) were used for patellar height measurement.[8,9] On the lateral view; the superior and inferior tips of patellar articular surface and the anterosuperior angle of tibial plateau are marked for CI. The ratio of the distance from the inferior tip of the patella and anterosuperior angle of the tibia to patellar articular surface length is called CI (mean value 0.96±0.134) (Figure 5b). The ISI was measured as ratio of patellar tendon length to patellar length (mean value 1.02±0.2) (Figure 5c).

Clinical evaluation

The Hospital for Special Surgery (HSS) and Lysholm knee scores were recorded pre- and postoperatively for all cases.[10,11] The satisfaction status of the cases were questioned at last visit.

Statistical analysis

The data was analyzed with the Wilcoxon paired two sample test and Pearson correlation test, by using Statistical Package for the Social Sciences (SPSS) for Windows version 10.0 (SPSS Inc., Chicago, Illinois, USA) and $p<0.05$ was accepted as significant.

RESULTS

Arthroscopic debridement and partial meniscectomy was carried out prior to osteotomy in four cases with mechanical symptoms.

A summary of evaluation values are listed in table I. The preoperative anatomical axis was corrected from

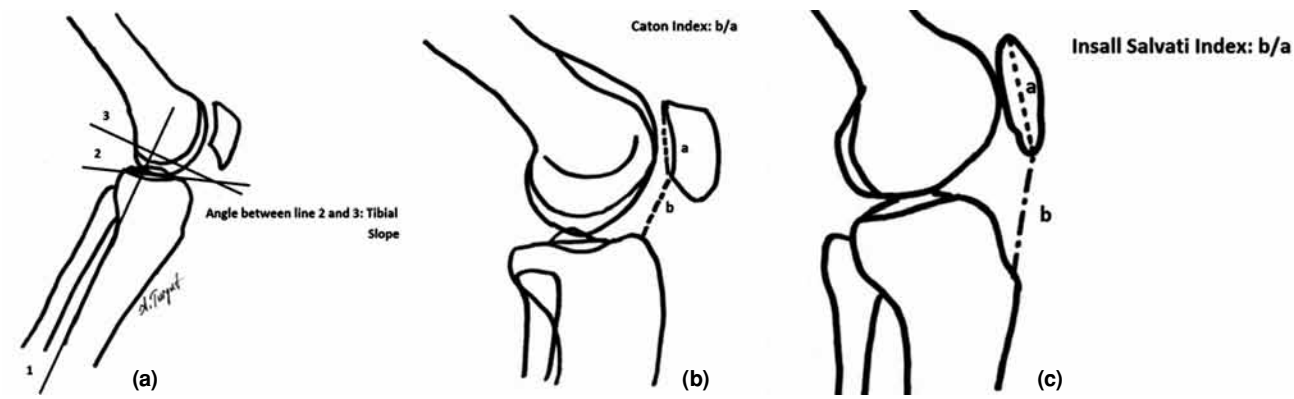

Figure 5. Measurement methods of **(a)** Tibial slope, **(b)** Caton index, **(c)** Insall-Salvati index.

6.3°±2.7° varus (range 2°-12°) to 10.8°±2.4° valgus (range 5°-16°) early postoperative and 7.2°±2.5° valgus (range 4°-14°) at the last visit. This correction was significantly different (p=0.0004).

The preoperative CI was 0.97±0.1 (range 0.75-1.21). It was measured as 0.96±0.1 (range 0.71-1.12) at the last visit. There was no significant difference between pre- and postoperative values (p=0.85). The pre- and postoperative ISI were 1.23±0.15 (range 0.97-1.50) and 1.14±0.15 (range 0.77-1.40) respectively. This difference was statistically significant (p=0.0125). However; only one ISI value was under the level of 0.8 that means patella baja (0.77).

Pre- and postoperative posterior tibial slope values were as follows; 6.5°±2.4° (range 2°-12°) and 0.06°±3.4° (range -6°-4°). We found a significant difference with regard to these values (p<0.0001).

We analyzed the correlation between frontal plane change (varus/valgus) and sagittal plane change (tibial slope) using the Pearson correlation test. There was no correlation between two parameters (r=-0.36, p=0.18). In addition, we analyzed the correlation of patellar tendon length change and tibial slope. There was no correlation observed (r=0.15, p=0.57). The preoperative HSS and Lysholm scores were improved from 57.4±4.9 (range, 46-63) to 88.6±6.1 (range, 73-95) and 56±4.2 (range, 51-65) to 84.6±8.3 (range, 71-95). There was a significant difference for both parameters (p<0.0001).

All the cases were satisfied with the treatment. They specified that their medial joint tenderness and anterior knee pain decreased. There was no complication related to surgical technique such as intra-articular fracture. None of the cases had peroneal paralysis, venous thromboembolism or infection. We obtained union at the osteotomy site in all cases.

DISCUSSION

Coventry reported that with HTO, the pain of degenerative arthritis of the knee can be relieved or reduced and the usefulness of the knee prolonged after getting satisfactory results in most of the patients.[2] Insall et al.[3] concluded the most important advantage is to supply limitless activity to patients and to avoid artificial joints. Whichever method is used, by relieving pain and increasing functional capacity, HTO must be considered in the treatment of knee osteoarthritis.[12]

Different HTO techniques have been described after its effectiveness was proven. Closed/open wedge, combined and dome osteotomy procedures were reported and recommended.[4,13,14] Most physicians were curious about the effects and results of these techniques on the frontal and sagittal planes.[5,14,15]

Scuderi et al.[15] measured ISI as 1.06 preoperative, 0.93 postoperative and Blackburne-Peel ratio as 0.93 preoperative, 0.84 postoperative in a series with 55 cases treated via closed wedge HTO. They found 11 (20%) patella baja according to ISI and five (9%)

TABLE I

Radiological data of the cases

	Preoperative				Last visit			
Case	Anatomical axis*	ISI	CI	Slope**	Anatomical axis*	ISI	CI	Slope**
1	-12°	1.2	1.2	4°	+8°	1.27	0.8	1°
2	-9°	1.28	1.0	7°	+4°	1.23	0.9	1°
3	-8°	1.27	0.8	12°	+6°	1.13	0.71	-6°
4	-7°	1.21	0.89	9°	+6°	1.02	0.9	-1°
5	-5°	0.97	0.93	5°	+8°	0.77	0.93	-6°
6	-6°	1.23	1.21	2°	+14°	1.21	1.06	1°
7	-5°	1.38	1.2	7°	+6°	1.31	1.06	4°
8	-6°	1.09	0.93	8°	+8°	0.97	0.87	4°
9	-7°	1.02	0.9	7°	+9°	1.09	1.12	2°
10	-2°	1.21	0.75	8°	+4°	1.10	1.0	0°
11	-4°	1.5	1.06	6°	+10°	1.12	1.0	4°
12	-2°	1.42	1.14	4°	+7°	1.31	1.0	-2°
13	-10°	1.07	0.83	6°	+6°	1.11	1.0	2°
14	-6°	1.45	0.96	8°	+5°	1.40	1.0	-5°
15	-6°	1.2	0.83	5°	+8°	1.19	1.10	2°

* (-) Refers to varus, (+) refers to valgus; ISI: Insall-Salvati index; CI: Caton index; ** (-) Refers to anterior slope.

according to Blackburne-Peel ratio. It was reported that ISI was decreased in 89% of the cases. It was stated that excessive callus formation during bony healing could lead to patellar tendon contracture.

In our study only one case (6%) had ISI as 0.77 and accepted patella baja. We observed decrease in ISI in 12 cases (80%) and decrease in CI in eight cases (53%). We believe excessive dissection of the patellar tendon leads to fibrosis and tendon contracture causing patella baja. Therefore we carried out as minimal dissection as possible around the patellar tendon.

In a comparative study of closed- and open-wedge HTO procedures, Brouwer et al.[16] reported higher rates of patella baja in open wedge HTO in contrast to the literature. The importance of tibial plateau elevation and change of tibial slope in open wedge HTO were pointed out in addition to reasons described above. It was found that postoperative cast application had no effect on patella baja formation.

Another radiological finding is change in tibial slope (increase or decrease). Increase in tibial slope may result in anteroposterior instability after total knee arthroplasty. Decreased tibial slope may result in increased load on the posterior cruciate ligament after total knee arthroplasty. It was reported that this condition leads to changes in knee kinematics and decreased knee range of motion.[17]

Hohmann et al.[18] applied closed wedge HTO on 67 cases. Preoperative tibial slope decreased from 6.2° to 1.2° postoperatively. They observed anterior tibial slope in 28% of cases. They could not find any correlation between frontal plane change and tibial slope change.

In our study; tibial slope decreased from 6.5° to 0.06°. We observed anterior slope in six cases (40%). Similarly, we did not find any correlation between frontal plane change and tibial slope change.

It is well known that changes in tibial slope arise from the triangle configuration of the proximal tibia. In the closed wedge technique; bone resection from the anterolateral part of the tibia leads to a decrease in tibial slope. In addition intact posterolateral support coming from the tibiofibular syndesmosis may result in decrease of slope. In contrast, while doing the open-wedge technique, application of the plate and/or bone graft on the anteromedial aspect of the tibia causes an increase in tibial slope.[19] Giffin et al.[20] emphasized that a slope change less than 5° does not increase the load on cruciates significantly. Hohmann et al.[18] specified there is no need to scrutinize tibial slope with closed-wedge HTO.

Cullu et al.[5] reported a decrease in tibial slope of 40 cases treated via dome osteotomy. They claimed decreased tibial slope should be considered while doing reconstructive procedures as total knee arthroplasty.

Kaper et al.[19] reported more or equal 5° tibial slope decrease in 61% and more than 10% loss of patellar height in 54% of 46 cases. Moreover they found a significant correlation between tibial slope decrease and loss of patellar height. However, in our study we could not find any correlation between patellar tendon length change and tibial slope.

In conclusion, non-intensive dissection around the patellar tendon may decrease patellar tendon contracture and patella baja risk. Although there is no correlation between frontal-sagital plane changes and also patellar tendon lenght change-tibial slope, an appropriate posterolateral resection may protect anatomic tibial slope as possible.

Declaration of conflicting interests

The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding

The authors received no financial support for the research and/or authorship of this article.

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