Eklem Hastalıkları ve Cerrahisi
Joint Diseases and Related Surgery

Original Article / *Özgün Makale*

Eklem Hastalık Cerrahisi
2012;23(3):128-133

Is proximal tibia the major problem in varus gonarthrosis? Evaluation of femur and ankle

Varus gonartrozunda en büyük sorun proksimal tibiada mıdır? Femur ve ayak bileğinin incelenmesi

Ahmet Issın, M.D., Vedat Şahin, M.D., Nizamettin Koçkara, M.D., Şükrü Sarper Gürsu, M.D., Ali Kurtuldu, M.D., Timur Yıldırım, M.D.

Department of Orthopedics and Traumatology, Metin Sabancı Bone Diseases Training and Research Hospital, İstanbul, Turkey

Objectives: In this study, we aimed to evaluate the components of knee varus in the adjacent joints and to investigate the possible correlations between them.

Patients and methods: Between January 2005 and December 2010, 315 lower limbs of 164 patients who underwent high tibial osteotomy (HTO) due to varus gonarthrosis were analyzed. Alignment and orientation angles of these limbs using preoperative orthoroentgenography were measured. The results were compared with normal values and evaluated statistically for possible correlations.

Results: Statistical analysis of the data showed that the mean value of mechanical lateral distal femoral angle (mLDFA) increases in varus knees and thus distal femoral joint orientation showed less valgus. The effect of mLDFA on mechanical tibiofemoral angle (mTFA) was almost the same as medial proximal tibial angle (MPTA). Both together; they explain 52.2% of variance in mTFA. mLDFA has a negative and MPTA has a positive and significant influence on mTFA (β= -0.765, p<0.001) and (β= 0.798, p<0.001) respectively. A moderate correlation was found between the mTFA and lateral distal tibial angle (LDTA) in the lower limbs grounding at the same angle (r=0.634, R=0.40, p<0.001). A slight, but significant correlation between mTFA and medial neck shaft angle (MNSA) was found (r=0.15, R=0.02, p<0.01).

Conclusion: Distal femoral joint showing less valgus significantly contributes to the deformity in varus gonarthrosis, also a very important contributor to the deformity. Abnormal forces applied to ankle may cause collapse in distal lateral tibial metaphysis and decrease LDTA in varus knees. Medial neck shaft angle may decrease due to possible abnormal loading angles to the femoral neck in some individuals with varus gonarthrosis.

Key words: Alignment; ankle; arthrosis; knee; lower limb; orthoroentgenography; varus.

Amaç: Bu çalışmada varus dizin komşu eklemlerdeki bileşenleri değerlendirildi ve bu bileşenler arasındaki muhtemel ilişki araştırıldı.

Hastalar ve yöntemler: Çalışmada, Ocak 2005 - Aralık 2010 tarihleri arasında, varus gonartrozu nedeniyle yüksek tibial osteotomi (YTO) yapılan 164 hastanın 315 alt ekstremitesi incelendi. Bu ekstremitelerin dizilim ve yönelim açıları ameliyat öncesi orthoröntgenografi ile ölçüldü. Sonuçlar normal değerler ile karşılaştırıldı ve aralarındaki ilişkiler istatistiksel olarak incelendi.

Bulgular: Yapılan istatistiksel değerlendirmelerde; varus dizlerde ortalama mekanik lateral distal femoral açının (mLDFA) arttığı, dolayısıyla femur distal eklem yüzünün daha az valgus gösterdiği görüldü. Mekanik tibiofemoral açı (mTFA) değişimi üzerinde mLDFA ve medial proksimal tibial açı (MPTA)'nın neredeyse eşit orandadır. Beraberce toplam %52.2'lik bir etkisi vardır. mLDFA'nın, mTFA değişimini ters yönde (b= -0.765, p<0.001), MPTA'nın, mTFA değişimini aynı yönde ve mLDFA'dan biraz daha fazla (b= 0.798, p<0.001) etkilediği görüldü. Aynı açı ile yere basan bacaklarda, mTFA ile lateral distal tibial açı (LDTA) arasında aynı yönde orta güçte bir ilişki olduğu görüldü (r=0.634, R=0.40, p<0.001). Mekanik tibiofemoral açı ile MNSA arasında aynı yönde zayıf, fakat önemli bir ilişki olduğu (r=0.15, R=0.02, p<0.01) tespit edildi.

Sonuç: Varus gonartrozunda femur distal eklem yüzünün olması gereken valgusu yeterince gösterememesi deformiteye önemli derecede katkıda bulunur. Ayak bileğinin anormal yüklenmesine bağlı olarak, distal lateral tibial metafiz bölgesinde de çökmeler görülür ve LDTA açısı düşer. Varus gonartrozu olan bazı bireylerde muhtemelen femur boynu yük değişimine bağlı olarak medial boyun şaft açısı azalır.

Anahtar sözcükler: Dizilim; ayak bileği; artroz; diz; alt ekstremite; ortoröntgenografi; varus.

• *Received: November 24, 2011 Accepted: February 06, 2012*

• Correspondence: Ahmet Issın, M.D. Metin Sabancı Baltalimanı Kemik Hastalıkları Eğitim ve Araştırma Hastanesi Ortopedi ve Travmatoloji Kliniği, 34470 Baltalimanı, İstanbul, Turkey. Tel: +90 505 - 764 83 00 Fax: +90 446 - 212 22 22 e-mail: ahmet.issin@gmail.com

Gonarthrosis and genu varum almost constantly coexist. Current studies about knee varus usually implicate already known tibial metaphyseal collapse, joint cartilage degradation and ligament laxity. Surgical or conservative treatment options for varus gonarthrosis all try to decrease abduction moment of the knee joint. Therefore, any change in lower extremity alignment which causes increased knee abduction moment might be a cause or effect of varus gonarthrosis. This study was planned to evaluate the factors leading to increased knee abduction moment and demonstrate possible relations between these factors and varus gonarthrosis.

PATIENTS AND METHODS

Two hundred and twenty-one patients who had undergone high tibial osteotomy (HTO) operation in our institute between January 2005 and December 2010 were evaluated. Fifty-seven patients who had complex deformities other than simple varus gonarthrosis or inappropriate orthoroentgenograms (such as those taken without weight bearing, with patellar rotation, or in which ankle or hip joints were obscure) were eliminated. Three hundred fifteen lower extremities of 164 patients were selected for the study. Two hundred and fifty-seven lower extremities of 134 females and 58 lower extremities of 30 males were measured; Mean age was 58 (range, 27-80) years.

Radiographic assessment

Radiographic assessment was made as described by Paley, mostly using his nomenclature.[1] The angle between the femoral and tibial mechanical axis was shown as mechanical tibiofemoral angle (mTFA), and the anatomical one as the anatomical tibiofemoral angle (aTFA). If the mTFA and aTFA were in varus direction negative numbers were used. Tangents were drawn on femoral and tibial condyles. The supplement of angle on the lateral side between the femoral tangential line and femoral anatomical axis was taken as the anatomical lateral distal femoral angle (aLDFA) and the femoral mechanical axis was taken as the mechanical lateral distal femoral angle (mLDFA). The supplement of angle between the line drawn from femoral neck center to femoral neck middle point and femoral anatomical axis was taken as the medial neck shaft angle (MNSA). The angle between the distal tibial joint surface orientation line and the ground surface was taken as the lateral distal tibial - ground surface angle (LDT-GSA). The supplement of angle on the medial side between the tibial mechanical (thus anatomical) axis and tibial condylar tangent line was taken as the medial proximal tibial angle (MPTA). The supplement of angle on the lateral side between the tibial anatomical axis and distal tibial surface orientation line was taken as the lateral distal tibial angle (LDTA) (Figure 1).

Statistical analysis

All data was analyzed using IBM PASW Statistics 18.0 version (SPSS Inc., an IBM Company, Chicago, IL, USA) software. Using the data, Shapiro-Wilk and Kolmogorov-Smirnov tests were used and histogram and QQ-Plot graphics were drawn to check how they resemble the normal curve. Pearson correlation test was used to find out relations between data. Within some variables, partial correlation tests were used. After grouping the data, Kruskal-Wallis and Mann-Whitney U tests were used to test if there was a significant difference between groups. After determining some relations between variables, mathematical relations were calculated by regression tests.

RESULTS

Three hundred fifteen lower extremities of 164 patients were measured. Mean values were calculated (Table I).

Data was separated into three groups depending on mTFA angles as >-5, -5≥ <-10 and ≤-10 respectively. Mean angles within the groups showed some difference (Table II). Data within the groups were not normally

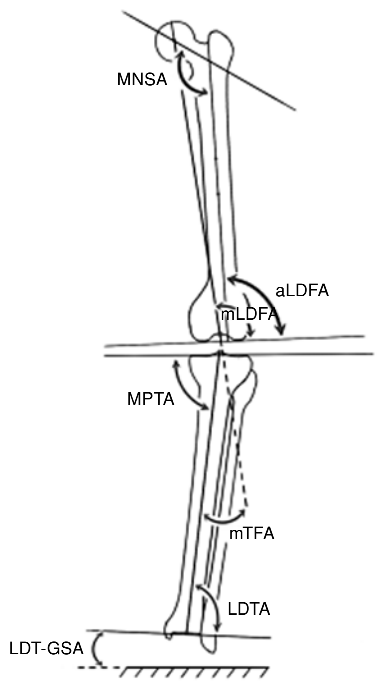

Figure 1. Radiographic measurements. MNSA: Medial neck shaft angle; mLDFA: Mechanical lateral distal femoral angle; aLDFA: Anatomical lateral distal femoral angle; MPTA: Medial proximal tibial angle; mTFA: Mechanical tibiofemoral angle; aTFA: Anatomical tibiofemoral angle; LDTA: Lateral distal tibial angle; LDT-GSA: Lateral distal tibial-ground surface angle.

TABLE I

Descriptive statistics of measured angles

	mTFA	aTFA	MNSA	aLDFA	mLDFA	MPTA	LDT-GSA	LDTA
Mean	-8.02	-1.76	124.71	83.71	89.98	85.38	-4.50	88.13
Median	-8.00	-2.00	124.00	84.00	90.00	85.00	-4.00	88.00
Standard deviation	4.925	4.855	6.352	3.153	3.106	3.558	4.313	4.118

mTFA: Mechanical tibiofemoral angle; aTFA: Anatomical tibiofemoral angle; MNSA: Medial neck shaft angle; aLDFA: Anatomical lateral distal femoral angle; mLDFA: Mechanical lateral distal femoral angle; MPTA: Medial proximal tibial angle; LDT-GSA: Lateral distal tibial-ground surface angle; LDTA: Lateral distal tibial angle.

distributed and variances were not homogenous. Thus, to check if this difference had significance, a non-parametric Kruskal-Wallis test was done and differences were found significant for all variables ($p<0.05$). Mann-Whitney U-test was more sensitive when comparing two groups. So the test was done between groups in pairs. Among the -5≥ <-10 and ≤-10 groups there was a significant difference between aLDFA, mLDFA, and LDT-GSA variables ($p<0.05$). Between the >-5 and 5≥ <-10 groups all variables were significantly different ($p<0.05$). As we pictured some relations between variables by drawing scatterplots, to determine the strength of the relations, correlation tests were done. As our variables did not display normal distribution, the Pearson correlation test (a parametric test resistant to divergence from normal distribution in large sets) was considered appropriate (Table III). We also compared the results with Spearman's correlation test and they were very similar with Pearson's. Table told us there are significant correlations within many variables. Correlation coefficient shall be between -1 and +1, 1 means a perfect linear correlation whether negative or positive. As seen on the table, correlation coefficient between mTFA and aTFA is 0.950. It is very close to 1 therefore shows almost perfect linear relation as an expected result. Correlation coefficient between MTPA and mTFA was 0.539 which means very strong linear relation. Partial correlation test between mTFA and mLDFA while MPTA is controlled, correlation coefficient rose to 0.571 from 0.438. When mLDFA is controlled and partial correlation test was done between mTFA and MPTA correlation coefficient rose to 0.640 from 0.539. As mTFA decreases -increase in varus- LDT-GSA also decreases, LDTA and LDT-GSA have a negative correlation and also mTFA and LDTA have a weak but significant correlation. So, to find out how it's going to be while LDT-GSA is controlled we applied a partial correlation test between mTFA and LDTA, and found a dramatic increase in correlation coefficient from 0.243 to 0.634. Regression analysis is designed to show the contribution of variables on a depended variable and prove the validity of results of correlation analysis. So to find out how MPTA and mLDFA changes affect mTFA we decided to do regression analysis. We did set our hypothesis, as "Contributors of knee varus are tibial medial metaphyseal collapse and also distal femoral orientation disorders". Results of regression analysis demonstrated that MPTA and mLDFA both have 52.2% of contribution on mTFA and using ANOVA table, this regression model was found significant at the $p<0.001$ level. Multiple regression analysis done with that hypothesis, showed that mLDFA and MPTA together affects 52.2% of mTFA value. Mechanical lateral distal femoral angle negatively affects mTFA (β= -0.765, $p<0.001$), and MPTA positively affects mTFA a little bit more than mLDFA does (β= 0.798, $p<0.001$).

DISCUSSION

One of the classical components of knee arthrosis is knee varus. Both conditions are somehow related but there is no exact proof of cause-effect relationship between them. Whether a cause or an effect, it is

TABLE II

Mean values of groups

Group		mTFA	aTFA	MNSA	aLDFA	mLDFA	MPTA	LDT-GSA	LDTA
<-10	(Mean)	-12.93	-6.25	123.80	84.74	91.08	83.28	-6.78	87.27
-5-10	(Mean)	-7.03	-0.92	124.43	83.60	90.06	85.92	-3.65	88.02
>-5	(Mean)	-1.97	3.88	126.59	82.29	88.14	87.78	-2.30	89.63
Total	(Mean)	-8.02	-1.76	124.71	83.71	89.98	85.38	-4.50	88.13

mTFA: Mechanical tibiofemoral angle; aTFA: Anatomical tibiofemoral angle; MNSA: Medial neck shaft angle; aLDFA: Anatomical lateral distal femoral angle; mLDFA: Mechanical lateral distal femoral angle; MPTA: Medial proximal tibial angle; LDT-GSA: Lateral distal tibial-ground surface angle; LDTA: Lateral distal tibial angle.

TABLE III

Pearson correlation test between variables

Pearson	mTFA	aTFA	MNSA	aLDFA	mLDFA	MPTA	LDT-GSA	LDTA
mTFA								
Correlation coefficient	1	0.950**	0.149**	-0.389**	-0.438**	0.539**	0.479**	0.243**
Significant *(p)*		0.000	0.008	0.000	0.000	0.000	0.000	0.000
aTFA								
Correlation coefficient	0.950**	1	0.050	-0.437**	-0.434**	0.540**	0.466**	0.211**
Significant *(p)*	0.000		0.374	0.000	0.000	0.000	0.000	0.000
MNSA								
Correlation coefficient	0.149**	0.050	1	0.096	-0.055	0.136*	0.085	0.004
Significant *(p)*	0.008	0.374		0.090	0.332	0.016	0.133	0.949
aLDFA								
Correlation coefficient	-0.389**	-0.437**	0.096	1	0.849**	0.067	-0.247**	0.074
Significant *(p)*	0.000	0.000	0.090		0.000	0.238	0.000	0.190
mLDFA								
Correlation coefficient	-0.438**	-0.434**	-0.055	0.849**	1	0.077	-0.244**	0.019
Significant *(p)*	0.000	0.000	0.332	0.000		0.173	0.000	0.732
MPTA								
Correlation coefficient	0.539**	0.540**	0.136*	0.067	0.077	1	0.201**	0.337**
Significant *(p)*	0.000	0.000	0.016	0.238	0.173		0.000	0.000
LDT-GSA								
Correlation coefficient	0.479**	0.466**	0.085	-0.247**	-0.244**	0.201**	1	-0.500**
Significant *(p)*	0.000	0.000	0.133	0.000	0.000	0.000		0.000
LDTA								
Correlation coefficient	0.243**	0.211**	0.004	0.074	0.019	0.337**	-0.500**	1
Significant *(p)*	0.000	0.000	0.949	0.190	0.732	0.000	0.000	

mTFA: Mechanical tibiofemoral angle; aTFA: Anatomical tibiofemoral angle; MNSA: Medial neck shaft angle; aLDFA: Anatomical lateral distal femoral angle; mLDFA: Mechanical lateral distal femoral angle; MPTA: Medial proximal tibial angle; LDT-GSA: Lateral distal tibial-ground surface angle; LDTA: Lateral distal tibial angle.

obvious that knee varus increases abduction moment on the knee, producing periarticular changes like medial ligament laxity and as a result accelerating degradation of joint cartilage.[2-6] Effects of knee varus on other joints are neglected and rarely have been a subject of a research. Early stage varus gonarthrosis in the middle age is usually successfully treated by correctional osteotomies. Those osteotomies (closed and open wedge or dome) are all focused on tibial metaphysis where the deformity is most obvious. Dome osteotomy even corrects both medial ligament laxity and alignment at the same time.[7,8] Successful results of those operations reinforce surgeons beliefs that they are on the right track; thus they may neglect other components of the condition. In this study, we found that as the varus in the knee increases, not only MPTA but also MPTA, LDTA, mLDFA and even MNSA angles change. This is obvious when knee varus difference is greater between groups. As we know, knee varus progresses in time and some patients are more vulnerable. As it happens in tibial metaphysis, abnormal static forces due to varus orientation applied to lower extremities might affect all bone and joint alignment properties in lower extremities. Cooke et al.[9] first mentioned the femoral component in varus gonarthrosis. They showed that femoral joint surface orientation also biased varus direction in varus gonarthrosis patients between two different populations. They even showed that in varus knees lateral femoral condyle was higher than medial condyle. This study also arrived at similar results. In our sample, in which mean mTFA angle was calculated 8° in varus direction, mean mLDFA was calculated at 90° which is in varus direction and higher than the normal value of 88.2° which Erdem et al.[10] documented in healthy Turkish people. Correlation tests also showed various levels of relations between angles and proved the findings. Also partial correlation tests were done to eliminate individual effects of various variables and even more remarkable results were found. In our study, regression tests showed that tibial and femoral components almost equally affect knee varus and both explain about 52.2% of the deformity; with the rest probably being due to other known components like thinned cartilage and ligament laxity. We did decide to undertake this research when we noticed the ankle joint line was not parallel to the ground on some postoperative orthoroentgenograms. As is the nature of closed chain movements, patients who have varus knees compensate for this deformity with valgus in their ankles and this causes abnormal forces on the ankle joint. These abnormal forces on the ankle joint might cause collapse in the distal lateral tibial metaphysis as similar forces on the knee joint cause collapse in the proximal medial tibial metaphysis. In those patients whose varus was greater, LDTA values were found less. Tarr et al.,[11] first commented about this issue, claiming that deformities of the distal one third of the tibia cause changes of the forces applied to the ankle.[11] A more recent article stated that, in patients who have unilateral ankle and knee arthrosis, a single HTO operation is useful to relieve both ankle and knee problems.[12] There are also some articles which point out the relation between gonarthrosis and ankle arthrosis. Tallroth et al.[13] showed that ankle arthrosis was present in 30% of patients they operated for gonarthrosis and concluded that bad alignment may affect both ankle and knee joints. In the ankle joint, coronal plane deformities are compensated by the subtalar joint. But if the deformity lasts long enough, this compensation mechanism becomes permanent.[14] Compensation of varus deformity on the coronal plane is harder than valgus deformity because the eversion capability of the subtalar joint is almost two folds less than the inversion capability.[15] This compensation mechanism of the ankle joint must be important to protect it from malalignment problems. The effect of alignment changes on ankle site on the knee joint is already known and is also a cause of closed chain mechanism. Conservative treatment modalities of knee arthrosis with wedged insoles, special shoes and braces all favor this. If those patients who had varus knees compensate with their subtalar joints and if this abnormal force distribution on ankle joints lasts long enough to cause collapse on the distal tibial metaphysis, it is likely that these patients have ankle problems after HTO operations. We also observed this issue in our patients- though some patients had abnormal ankle joint orientation before operation, others had rather normal orientation even though they had excessive knee varus. Therefore, in order not to provoke ankle problems after HTO operations, their timing may be more important than we thought before. Takeuchi et al.[12] showed both ankle and knee problems were relieved in 10 of 16 patients who had ipsilateral varus gonarthrosis and ankle arthrosis after an HTO operation alone. This result also supports that HTO operation with a good timing may be protective for lower extremity problems other than the knee. In this retrospective study, patients were not questioned about ankle problems either before or after the HTO operation. But patients are mostly focused on the major knee problem and may overlook their lesser ankle pain. Prospective researches should be done to investigate this question.

In conclusion, in varus gonarthrosis, patients' varus should not be considered as a problem of the knee alone. It should be regarded as a problem of the whole lower extremity considering its effects on neighboring joints. Furthermore in varus knees, it should be remembered that tibial deformity is not the only factor responsible for the varus alignment as the malalignment of the femoral side also contributes to this pathology as much as the tibial side.

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.

REFERENCES

1. Paley D. Radiographic assessment of lower limb deformities. In: Herzenberg JE, editor. Principles of deformity correction. Baltimore: Springer: 2003. p. 31-60.
2. Andriacchi TP. Dynamics of knee malalignment. Orthop Clin North Am 1994;25:395-403.
3. Guettler J, Glisson R, Stubbs A, Jurist K, Higgins L. The triad of varus malalignment, meniscectomy, and chondral damage: a biomechanical explanation for joint degeneration. Orthopedics 2007;30:558-66.
4. Miller EJ, Riemer RF, Haut Donahue TL, Kaufman KR. Experimental validation of a tibiofemoral model for analyzing joint force distribution. J Biomech 2009;42:1355-9.
5. Mina C, Garrett WE Jr, Pietrobon R, Glisson R, Higgins L. High tibial osteotomy for unloading osteochondral defects in the medial compartment of the knee. Am J Sports Med 2008;36:949-55.
6. Witvrouw E, Danneels L, Thijs Y, Cambier D, Bellemans J. Does soccer participation lead to genu varum? Knee Surg Sports Traumatol Arthrosc 2009;17:422-7.
7. Güneş T, Şen C, Bostan B, Erdem M, Kalaycıoğlu A. Efficacy of proximal tibial focal-dome type osteotomy on medial joint laxity. Eklem Hastalik Cerrahisi 2008;19:72-7.
8. Erdem M, Güneş T, Sen C, Bostan B, Aşçi M. Opening focal dome osteotomy in the treatment of varus gonarthrosis associated with medial laxity. [Article in Turkish] Eklem Hastalik Cerrahisi 2010;21:80-5.
9. Cooke TD, Harrison L, Khan B, Scudamore A, Chaudhary MA. Analysis of limb alignment in the pathogenesis of osteoarthritis: a comparison of Saudi Arabian and Canadian cases. Rheumatol Int 2002;22:160-4.
10. Erdem M, Şen C, Güneş T, Bostan B. Tokat ili ve çevresinde yaşayan kişilerde alt ekstremite aksiyel dizilimine ait veriler. Eklem Hastalik Cerrahisi 2008;19:18-23.

11. Tarr RR, Resnick CT, Wagner KS, Sarmiento A. Changes in tibiotalar joint contact areas following experimentally induced tibial angular deformities. Clin Orthop Relat Res 1985;199:72-80.
12. Takeuchi R, Saito T, Koshino T. Clinical results of a valgus high tibial osteotomy for the treatment of osteoarthritis of the knee and the ipsilateral ankle. Knee 2008;15:196-200.
13. Tallroth K, Harilainen A, Kerttula L, Sayed R. Ankle osteoarthritis is associated with knee osteoarthritis. Conclusions based on mechanical axis radiographs. Arch Orthop Trauma Surg 2008;128:555-60.
14. Hennessy MS, Molloy AP, Wood EV. Management of the varus arthritic ankle. Foot Ankle Clin 2008;13:417-42.
15. Rush SM. Supramalleolar osteotomy. Clin Podiatr Med Surg 2009;26:245-57.