Original Article
Cent Asian J Med Sci. 2019 March;5(1):22-29. https://doi.org/10.24079/CAJMS.2019.03.004

Central Asian Journal of Medical Sciences
CAJMS

Early Results of High Tibial Osteotomy for Osteoarthritis in Mongolia

Tuvshinjargal Boldbayar, Dashtsogt Sodnompil, Enkhtaivan Narangerel, Bayartsengel Ulziibat, Otgonbayar Maidar, Sergelen Orgoi

The Joint Center, The First Central Hospital of Mongolia, Ulaanbaatar, Mongolia

Submitted: January 31, 2019
Revised: February 17, 2019
Accepted: March 26, 2019

Corresponding Author
Tuvshinjargal Boldbayar, MD
The Joint Center, The First Central Hospital of Mongolia, Ulaanbaatar 14910, Mongolia
Tel: +976-88320099
E-mail: tuja_2007@yahoo.com

Objectives: The objectives of this study were to examine the reproducibility of the surgical correction and pain relief following high tibial osteotomy for osteoarthritis. **Methods:** Twenty-seven patients who underwent high tibial osteotomy at The First Central Hospital of Mongolia were included. Patients divided into three groups based on their osteoarthritis grade using the Kellgren Lawrence classification. The weight-bearing line and medial proximal tibial angle were used for preoperative planning to assess postoperative correction. Oxford knee scores were used to assess knee pain and function. **Results:** The weight-bearing line and medial proximal tibial angle measurements at both postoperative time intervals were significantly different from the preoperative values ($p<.001$) but were not significantly different from each other. The Oxford knee scores were 31.54±6.3 preoperatively, 34.82±4.3 at two months after the surgery and improved to 40.89±2.7 six months after the surgery. Statistically significant successive improvements in scores were observed at each time interval ($p<.001$). **Conclusion:** High tibial osteotomy can be done with rigid internal fixation and can improve function and reduce pain in Mongolian patients with early arthritis without affecting joint range of motion.

Keywords: High Tibial Osteotomy, Medial Proximal Tibial Angle, Knee Osteoarthritis, Weight Bearing Line, Weight Bearing Axis

Introduction

The knee is divided into medial and lateral compartments consisting of femoral and tibial condyles with a high prevalence of medial compartment arthrosis as humans age. The forces on the cartilage in the medial compartment are highly dependent on the mechanical alignment of the leg with bowing at knee causing a dramatic increase in the risk of arthrosis[1]. High tibial osteotomy (HTO) is a widely performed procedure to treat medial knee arthrosis[2-4]. First introduced by Jackson and Waugh in 1961, high tibial osteotomy was made popular by Conventry in 1965 and has since been used as a treatment modality for medial compartment osteoarthritis of the knee with varus deformity[5,6]. HTO surgery consists of cutting the proximal tibia just below the tibial plateau and straightening the lower extremity to correct bowing, thus altering the way the forces are distributed through the knee.

The goals of HTO are twofold: 1) to reduce knee pain by transferring weight-bearing loads to the relatively unaffected lateral compartment in knees with varus deformity; and 2) to delay the need for a knee replacement by slowing or stopping the destruction of the medial compartment caused by increased medial forces resulting from malalignment[7].

Appropriate patient selection is key to a successful HTO. Primary or secondary medial compartment degenerative arthritis is the most common indication for HTO. The ideal candidate for HTO is thought to be an individual who is between 60 to 65 years of age with isolated medial osteoarthritis with a varus deformity and good range of motion (ROM) and without ligamentous instability[8].

HTO has been performed at The First Central Hospital of Mongolia for two years. There are no well-defined criteria or unified understanding for choosing patient for HTO. It is controversial to perform HTO for early or end-stage osteoarthritis. The primary objective of HTO is to reduce pain by reducing the force in the medial compartment of the knee by changing the alignment of the knee from bowed to the normal slightly knock-knee alignment as shown in Figure 1 and 2.

We are unaware of any peer-reviewed published HTO related studies done in Mongolia although some investigations have been done in conjunction with arthroscopic surgery during HTO but they did not illustrate the effect of OA grade on the outcome HTO. The purpose of our study was to compare the early clinical outcomes of HTO in patients with grade I, grade II and grade III osteoarthritis.

Material and Methods

Twenty-seven patients who underwent HTO in The First Central Hospital of Mongolia were involved agreed to participate in our cross-sectional study with repeated measurements. Patients divided into Groups 1, 2, and 3 corresponding to their grade of osteoarthritis using Kellgren Lawrence classification (Figure 3)[9]. There was no patient with Grade 0 and Grade 4. The Oxford knee score was assessed pre and postoperatively. Standing long leg alignment X-rays were used to determine the weight-bearing line (WBL), medial proximal tibial angle and these were used to compare surgical outcomes for each group. The Miniaci method was used preoperatively to plan the amount of opening required to achieve angular correction[10].

The contraindications for the procedure were OA grade O and IV, restricted range of motion of the knee with flexion less than 90^{o} or a flexion contracture of 15^{o} or more, and severe anterior knee pain.

Surgical technique

All patients underwent medial opening wedge osteotomy with rigid fixation using a special plate and screws designed for HTO surgery (OhtoFix®, South Korea). The plate permitted the attachment of a small metal wedge of various thicknesses which held the medial bone cortices apart during healing of the osteotomy. The osteotomy site was typically not filled with bone graft or bone substitute.

Weight bearing axis calculation

In lower extremities the mechanical axis is determined by measuring the angle between the line drawn through the center of the femoral head and center of the knee with the line drawn from the center of the knee to the center of the ankle. In knees with a normal mechanical axis, this is a straight line and the angle between lines mentioned is zero. In patients with medial arthrosis, the alignment is varus (i.e., angled away from the midline). The ideal postoperative mechanical axis following HTO is 3^{o} to 5^{o} of valgus (i.e., angled towards the midline) or 8^{o} to 10^{o} of anatomical valgus in most studies. Fujisawa et al. reported that the postoperative mechanical axis should pass through the lateral one-third of the tibial plateau at a location known as the Fujisawa point which is 62.5 percent of the width of the tibial plateau measured from the medial edge of the tibial plateau (Figure 4)[11-14]. This shifts the mechanical axis from the medial compartment to the lateral compartment as shown in Figure 4 which redistributes some of the forces from the medial compartment to the lateral compartment. Figure 5 shows the comparison between preoperative weight-bearing line and post-operative weight-bearing line.

Medial proximal tibial angle

The medial proximal tibia angle is defined as the angle between the tibial mechanical axis and the articular surface of the tibial plateau. A known complication of HTO is the recurrence of varus deformity and this related to the medial proximal tibial angle which is 87^{o} (85^{o} - 90^{o}) normally[15]. Previous studies have shown

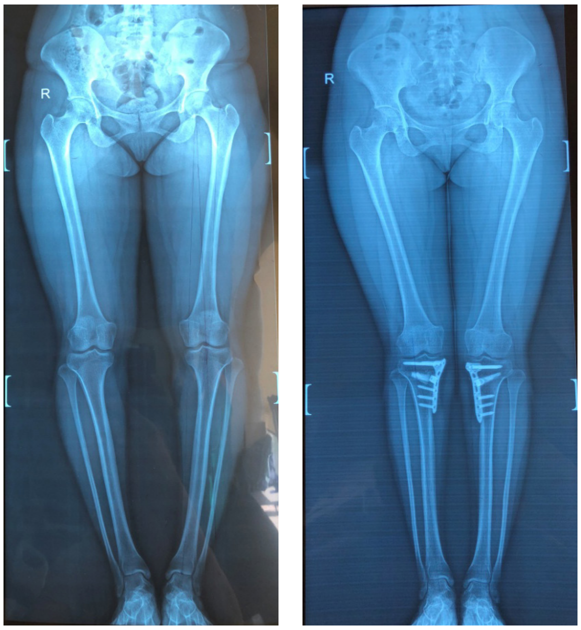

Figure 1. X-ray image A) before and after B) HTO.

Figure 2. Photograph showing the change in alignment A) before and B) after HTO.

Grade	Description
0	Normal
1	Doubtful narrowing of joint space, possible osteophytic lipping
2	Definite osteophytes, possible narrowing of the joint space
3	Moderate multiple osteophytes, definite narrowing of joint space, small pseudocystic areas with sclerotic walls and possible deformity of bone contour
4	Large osteophytes, marked narrowing of joint space, severe sclerotic and definite deformity of bone contour

Figure 3. Kellgren-Lawrence radiographic grading system for osteoarthritis.

that the rate of recurrence of varus deformity is the lowest when medial proximal tibial angle corrected to 95^{o} and this was also an objective during HTO surgery (Figure 6)[16].

Measurements

Demographic data were gathered for the patients. Knee pain and function were measured using the Oxford knee score. The osteoarthritis in each knee was radiographically quantified using the Kellgren Lawrence classification[9]. Their knee range of motion was measured[17]. The mechanical axis was measured from standard weight-bearing alignment X-rays. From this, the percent distance of the weight-bearing line from the medial edge of the tibia and medial proximal tibial angle was measured. Each of these measurements were obtained preoperatively, and at 2 and 6 months after surgery.

Statistical analysis

Data were presented as mean±standard deviation. All quantitative data were tested for normality using the Kolmogorov–Smirnov test. Since the Kolmogorov–Smirnov testing identified that only data from one of the three different intervals for each variable was normally distributed, non-parametric tests were used throughout the analysis. We used Friedman test as a non-parametric alternative to two-way repeated measures ANOVA to detect differences between groups and repeated measurements across time intervals. The Wilcoxon signed rank test was used to make multiple comparisons assessing paired differences in repeated measurements and comparisons between groups. All analyses were performed using IBM SPSS Statistics version 23 software.

Ethical statements

Ethical approval for this study was obtained from the Institutional

Figure 4. X-ray image showing the Fujisawa point which is 62.5 percent of the width of the tibial plateau measured from the medial edge of the tibial plateau.

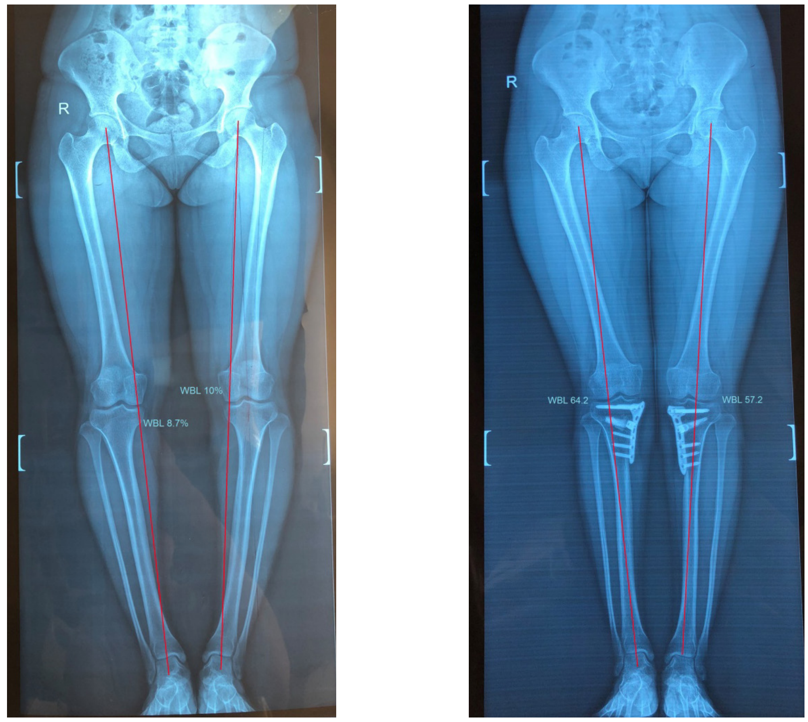

Figure 5. X-ray images showing the pre- and postoperative weight-bearing line.

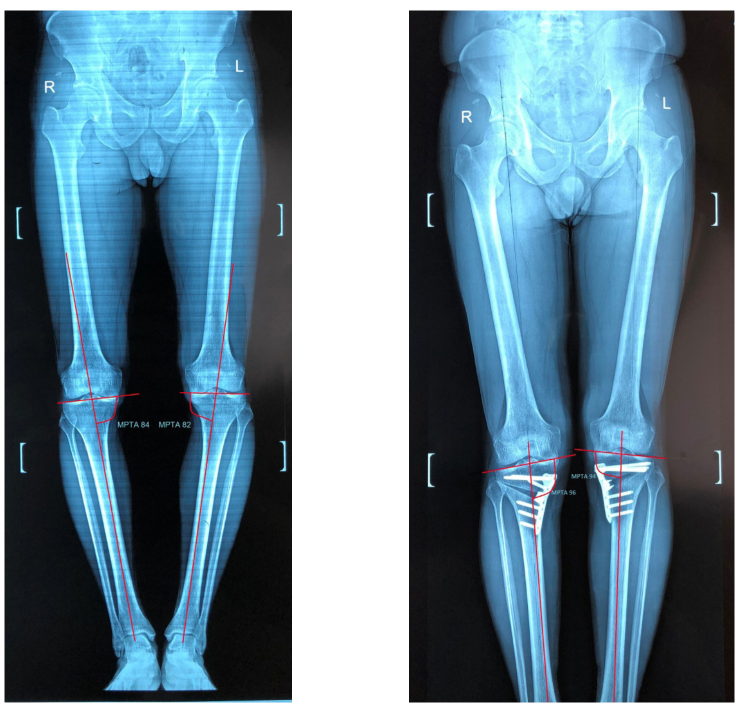

Figure 6. X-ray images showing the medial proximal tibial angle (A) 84° on the right and 82° on the left preoperatively and (B) corrected to 96° on the right and 94° on the left postoperatively.

Table 1. Comparison of baseline demographics and grade of osteoarthritis in study participants.

Variable	Osteoarthritis Grade			Total
	Grade I N (%)	Grade II N (%)	Grade III N (%)	
Gender				
Male	0 (0.0)	2 (40.0)	12 (80.0)	14
Female	6 (100.0)	3 (60.0)	3 (20.0)	15
Age				
<49	6 (100.0)	3 (60.0)	0 (0.0)	9
>50	0 (0.0)	2 (40.0)	15 (100.0)	17
Body mass index				
Normal weight	0 (0.0)	3 (60.0)	3 (20.0)	6
Overweight	0 (0.0)	2 (40.0)	8 (53.3)	10
Obese	6 (100.0)	0 (0.0)	4 (26.7)	10

Review Board of The First Central Hospital of Mongolia (2019.01.29).

Results

The baseline demographics of age, gender, body mass index and the osteoarthritis grade are compared for each group in Table 1. The median age was 54 years, there were four times as many women as men and over half of the patients had Grade III OA.

The multiple comparisons in Table 2 show that the knee flexion and extension was reduced at 2 months after the surgery but there was no difference at 6 months follow-up.

The percent distance of the weight-bearing line from the medial edge of the tibial plateau preoperatively was 12.58%±14.8, at 2 months follow-up was 59.95±4.1 percent and was again 60.15±3.8 percent at 6 months follow-up. The postoperative percent distance of the weight-bearing line from the medial edge of the tibial plateau measurements at both time intervals was significantly different from the preoperative values (p<.001) but was not significantly different from each other indicating no change in the alignment between 2 and 6 months.

The medial proximal tibial angle preoperatively was $83.80±3.2^0$, at 2 months after surgery was $93.7±2.8^0$ and was $93.05±3.1^0$ at 6 months following surgery. Like the percent distance of the weight-bearing line from the medial tibial plateau, the postoperative medial proximal tibial angle measurements at both postop time intervals were significantly different from the preoperative values (p<.0001) but were not significantly different from each other.

The Oxford knee scores were 31.54±6.3 preoperatively, 34.82±4.3 at 2 months after the surgery and improved to 40.89±2.7 after the surgery. There was a statistically significant

Table 2. Repeated measurements of knee alignment, motion, and function at the different time intervals.

Variables	Measurement Interval			p-value†
	Preoperative mean±SD	2 months after surgery mean±SD	6 months after surgery mean±SD	
WBL%	12.58±14.8	59.95±4.1	60.15±3.8	<.001
MPTA	83.80±3.2	93.7±2.8	93.05±3.1	<.001
Extension	2.80±2.7	4.65±2.9	2.95±2.2	<.001
Flexion	114.42±15.9	94.78±9.7	114.11±15.9	<.001
Oxford knee score	31.54±6.3	34.82±4.3	40.89±2.7	<.001

†p-value using the Friedman test. WBL is the weight-bearing line; MPTA is the medial proximal tibial angle. Multiple comparisons are shown in Table 2.

Table 3. Multiple comparisons between the pre- and postoperative measurement results (n=26).

Measurement intervals	Z	p-value†
$WBL\%_0$ x $WBL\%_1$	-4.1	<.0001
$WBL\%_0$ x $WBL\%_2$	-3.8	<.0001
$WBL\%_1$ x $WBL\%_2$	-1.5	.62
$MPTA_0$ x $MPTA_1$	-4.2	<.0001
$MPTA_0$ x $MPTA_2$	-3.8	<.0001
$MPTA_1$ x $MPTA_2$	-0.8	.48
$Extension_0$ x $Extension_1$	-3.5	<.0001
$Extension_0$ x $Extension_2$	0.0	1.0
$Extension_1$ x $Extension_2$	-3.6	<.0001
$Flexion_0$ x $Flexion_1$	-4.1	<.0001
$Flexion_0$ x $Flexion_2$	-3.8	<.0001
$Flexion_1$ x $Flexion_2$	-3.8	<.0001
Oxford knee $score_0$ x Oxford knee $score_1$	-3.7	<.0001
Oxford knee $score_0$ x Oxford knee $score_2$	-3.8	<.0001
Oxford knee $score_1$ x Oxford knee $score_2$	-3.8	<.0001

$_0$Preoperative, $_1$2 months after surgery, $_2$6 months after surgery; †p-value using the Wilcoxon sign rank test. The measurements used for these comparisons are shown in Table 1.

successive improvement in the score at each time interval (p<.001) (Table 3).

One superficial infection occurred after the surgery, and it successfully treated conservatively without additional surgery.

Discussion

High tibial osteotomy is effective for early osteoarthritis as long as it is grade III or less[18]. Previous investigators have shown that the Oxford knee score increased the most when the weight-bearing line transferred to Fujisawa point (62.5%) and medial proximal tibial angle corrected to 95^0 as well as they demonstrated knee osteoarthritis if diagnosed early, can be successfully treated by performing high tibial osteotomy to preserve knee joint[19].

In this study we found the initial range of motion decreased in early in the post-operative period followed by full recovery of motion at 6 months after the surgery. The percent distance of the weight-bearing line from the medial edge of the tibial plateau and medial proximal tibial angle was largely corrected by the surgery and there was no change in either measurement between 2 and 6 months after the surgery indicating the surgical technique used provided stable, rigid internal fixation during the critical period of healing for fractures and osteotomies. Most importantly, our study found that HTO improved knee function and reduced pain at both 2 months and 6 months following surgery as measured by the progressive improvement in Oxford knee scores. These improvements are similar to those of studies in the developed world[20,21].

We had a low incidence of complications with only one superficial infection. The risks of HTO are small and include infection, blood clots, non-union, pain over the hardware, and nerve or vascular injury. All patients have a scar and a slight change in leg length. Although not measured in our study, patients may feel that straightening their leg results in improved appearance.

While our study has shown the benefit of short-term pain relief, long-term follow-up is required to see if HTO durable treatment option in our patients. We have not demonstrated that HTO prevents the progression of arthritis. However, previous studies have shown that if the limb malalignment is corrected to the ideal angle it can delay the need for a knee replacement for several years. This is particularly beneficial for patients in their 40's or 50's where knee replacement often fail within a few years of surgery.

Our study is limited by the small sample size and time due to recently increased utilization of HTO in Mongolia. Furthermore, outcomes of alternative surgeries including closing wedge high tibial osteotomy, unicondylar knee replacement are controversial[22]. Thus, further studies are necessary to assess mid- and long-term outcome of HTO as well as a comparison between HTO and its alternative surgeries.

Conclusion

This study has shown that high tibial osteotomy can be done with rigid internal fixation and that it improves function and reduces pain in Mongolian patients with early arthritis without affecting joint range of motion.

Conflict of Interest

The authors state no conflict of interest.

Acknowledgements

We thank Dr. Ron Anderson, a volunteer worker with Deseret International Charities, for help with the preparation of this manuscript and Dr. Mandukhai Ganbat of The Mongolian National University of Medical Sciences for help with the statistical analysis.

References

1. Sharma L, Chmiel JS, Almagor O, Felson D, Guermazi A, Roemer F, et al. The Role of Varus and Valgus Alignment in the Initial Development of Knee Cartilage Damage by MRI: the MOST Study. Ann Rheum Dis 2013; 72: 235-40. doi:10.1136/annrheumdis-2011-201070.
2. Amendola A, Bonasia DE. Results of high tibial osteotomy: review of the literature. Int Orthop 2010; 34: 155–60. doi:10.1007/s00264-009-0889-8.
3. Brinkman JM, Lobenhoffer P, Agneskirchner JD, Staubli AE, Wymenga AB, van Heerwaarden RJ. Osteotomies around the knee: patient selection, stability of fixation and bone healing in high tibial osteotomies. J Bone Joint Surg Br 2008; 90: 1548–7. doi: 10.1302/0301-620X.90B12.21198.
4. Hernigou P, Medevielle D, Debeyre J, Goutallier D. Proximal tibial osteotomy for osteoarthritis with varus deformity: A ten to thirteen-year follow-up study. J Bone Joint Surg Am 1987; 69: 332–54.
5. Jackson JP, Waugh W. Tibial osteotomy for osteoarthritis of the knee. J Bone Joint Surg Br 1961; 43: 746-51.
6. Conventry MB. Osteotomy of the upper portion of the tibia for degenerative arthritis of the knee. A preliminary report. J Bone Joint Surg Am 1965; 47: 984-90.
7. Lee DCH, Byun SJ. High tibial osteotomy. Knee Surg Relat Res 2012; 24: 61-9.
8. Rossi R, Bonasia DE, Amendola A. The role of high tibial osteotomy in the varus knee. J Am Acad Orthop Surg 2011; 19: 590-9.
9. Altman R, Asch E, Bloch D, Bole G, Borenstein D, Brandt K, et al. Development of criteria for the classification and reporting of osteoarthritis. Classification of osteoarthritis of the knee. Diagnostic and Therapeutic Criteria Committee of the American Rheumatism Association. Arthritis Rheum 1986; 29: 1039–49.
10. Yoon SD, Zhang GF, Kim HJ, Lee BJ, Kyung HS. Comparison of Cable Method and Miniaci Method Using Picture Archiving and Communication System in Preoperative Planning for Open Wedge High Tibial Osteotomy. Knee Surg Relat Res 2016; 28: 283-8.
11. Bauer GC, Insall J, Koshino T. Tibial osteotomy in gonoarthrosis (osteo-arthritis of the knee). J Bone Joint Surg Am 1969; 51: 1545-63.
12. Fujisawa Y, Masuhara K, Shiomi S. The effect of high tibial osteotomy on osteoarthritis of the knee. An arthroscopic study of 54 knee joints. Orthop Clin North Am 1979; 10: 585608.
13. Macintosh DL, Welsh RP. Joint debridement - complement to high tibial osteotomy in the treatment of degenerative arthritis of the knee. J Bone Joint Surg Am 1977; 59: 1094-7.
14. Conventry MB. Upper tibial osteotomy for osteoarthritis. J Bone Joint Surg Am 1985; 67: 1136-40.
15. Paley D. Principles of deformity correction. Realignment for mono-compartment osteoarthritis of the Knee. New York, United States: Springer-Verlag; 2002. p 479–485.
16. Pornrattanamaneewong CH, Narkbunnam R,

Chareancholvanich K. Medial proximal tibial angle after medial open wedge HTO: A retrospective diagnostic test study. Indian J Orthop 2012; 46: 525-30. doi: 10.4103/0019-5413.101042.
17. Reito A, Järvistö A, Jämsen E, Skyttä E, Remes V, Huhtala H, et al. Translation and validation of the 12-item Oxford knee score for use in Finland. BMC Musculoskelet Disord 2017; 18: 74.
18. Takahara Y, Itani S, Uchida Y, Nakamura M, Ochi N, Kato H, et al. Mid term result of OWHTO regarding from KL stage. The 5th Korea – Japan knee osteotomy symposium 2018; p 165.
19. Akiyama T, Nakamura SH, Okazaki K. The timing of around the knee osteotomy for the early OA. The 5th Korea – Japan knee osteotomy symposium 2018; p 115.
20. Hui C, Salmon LJ, Kok A, Williams HA, Hockers N, van der Tempel WM, et al. Long-term survival of high tibial osteotomy for medial compartment osteoarthritis of the knee. Am J Sports Med 2011; 39: 64-70.
21. Floerkemeier S, Staubli AE, Schroeter S, Goldhahn S, Lobenhoffer P. Outcome after high tibial open-wedge osteotomy: a retrospective evaluation of 533 patients. Knee Surg Sports Traumatol Arthrosc 2013; 21: 170-80.
22. Amendola A, Bonasia DE. Results of high tibial osteotomy: review of the literature. Int Orthop 2010; 34: 155–60. doi: 10.1007/s00264-009-0889-8.