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Mid-Term Results of High Tibial Osteotomy Regarding From Grades of Knee Osteoarthritis

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Objectives: The number of high tibial osteotomy (HTO) has significantly increased in Mongolia, however, researchers are still debating about the impact of severity of knee osteoarthritis on the outcome of high tibial osteotomy. The purpose of our study is to report the mid-term results of HTO for knee osteoarthritis according to the Kellgren Lawrence classification. **Methods:** A total of 100 patients who underwent high tibial osteotomy for knee osteoarthritis from October 2019 to June 2020 at the Joint Center of the First Central Hospital of Mongolia participated in this study. Outcome evaluation of the participants was accomplished at baseline, at 2 months, 6 months, 8 months and 18 months post-operatively. **Results:** Lateral closing wedge HTO was performed in 54.2 % of patients who had 1st grade deformity and 55.9 % of patients who had 2nd grade deformity. On the other hand, medial opening wedge HTO was performed in 3rd grade patients compared to other grades. WBL was 11.43 ± 8.22 at preoperative, and increased to 56.31 ± 4.52 after 12 months of the surgery in 3rd grade. The total WBL was improved from 20.54 ± 12.57 to 57.24 ± 3.69 after two months of surgery and 57.89 ± 4.17 after 12 months. **Conclusion:** Our study showed that the severity of knee osteoarthritis had impact on outcome of high tibial osteotomy.

Keywords: Knee Joint, Osteoarthritis, Arthritis, Joint Diseases, Orthopedics, Musculoskeletal Diseases

Introduction

Osteoarthritis (OA) is the most common form of arthritis and results in disability particularly in elderly populations [1 - 4]. It has been demonstrated that knee OA is a classic age-related disorder and further increases with longer lifetime and higher average weight of the population. Meta-analysis covering 88 studies with 10,081,952 participants showed that the pooled global prevalence of knee OA is 16.0 % in individuals aged 15 and over, and 22.9 % in individuals aged 40 and over. The pooled global incidence of knee OA was 203 per 10,000 person-years in individuals aged 20 and over, and the prevalence was different between individual countries and increased with age. Also, several cross-sectional studies revealed a significant

relationship between lifestyle and knee OA [5 - 7]. Coggon et al. presented that, relative to a body mass index (BMI) of 24.0 - 24.9 kg/m^2, the risk of knee OA increased progressively from 0.1 for a BMI < 20 kg/m^2 to 13.6 for a BMI of 36 kg/m^2 or higher. If all overweight and obese people reduced their weight by 5 kg or until their BMI was within the recommended normal range, 24 % of surgical cases of knee OA might be avoided [8]. A scoping review by Zamri et al. also demonstrated that the overall prevalence of OA is in a range of 20.5 % to 68.0 % in Asia. Risk factors that have been associated with OA are advanced age, being female and obesity [9].

High tibial osteotomy (HTO) is a popular surgery to correct various deformations associated with compartmental osteoarthritis. Within this procedure, the weight bearing load is shifted from the arthritic portion to the viable articular cartilage portion, and as a result, the mechanical axis is corrected and passed through the lateral compartment. In the retrospective cohort study of van Wulfften Palthe et al. survival at 10 years after HTO was 75 and 55 % at 15 years and less than 40 % at 20 years. Age of 50 years or more, female gender and surgical technique are significant independent predictors of failure [10]. In another meta-analysis, where the patients underwent open or closed wedge HTO with more than 5 - year follow-up duration, the pooled 5 - year survival rates were 95.1 % in open wedge HTO and 93.9 % in closed wedge HTO. Further, pooled 10 - year survival rates were 91.6 % in open wedge HTO and 85.4 % in closed wedge HTO, indicating that open wedge HTO had 6.2 % greater survival rate 10 years after surgery than did closed wedge HTO [11]. The prospective cohort study of medial open-wedge high tibial osteotomy in the Chinese population showed clinical outcome of 1 - year postoperative follow-up and at last follow-up. At 10-year follow-up, four knees converted to require total knee arthroplasty (survival: 87.1 %) and Knee Society knee score was increased significantly from 53.7 % preoperatively to 93.8 % at 1-year follow-up and 91.8 % at latest follow-up [12].

Kellgren-Lawrence scale is widely used for a validation of hip and knee osteoarthritis now days as referenced by the World Health Organizations. The scale is described as follows: grade 0: normal joint; grade 1: minute osteophytes of doubtful significance; grade 2: definite osteophytes; grade 3: moderate diminution of joint space; grade 4: joint space greatly impaired, subchondral sclerosis. There are significantly few studies evaluating the outcomes of HTO on the Kellgren-Lawrence scale. Effect of the preoperative Kellgren-Lawrence grade on mid-term to long-term outcome in interlocking closing - wedge HTO in Japanese patients was studied and resulted in overall survival rates of HTO with 99.2 % at 5 years, 93.8 % at 10 years. The survival rates of grade 3 was 99.9 % at 5 years, 98.1 % at 10 years. The survival rates of grade 4 was 97.9 % at 5 years, 98.1 % at 10 years. There was a significant difference between the grade 3 and 4 participants [13]. The follow-up study of open-wedge HTO on grade 4 patients showed no complications in HSS score of knee function such as vascular and nerve injury, internal fixation fracture or infection after 2-year follow-up. The (89.6 %) at the last follow-up after operation was higher than (63.2 %) points before operation [14]. Another long-term follow-up of closing wedge HTO showed that the survival of HTO was 84 % after 9.6 years and knee function was considered excellent or good in 64 % of patients. Moreover, a significant preoperative risk factor for HTO failure was osteoarthritis, Kellgren-Lawrence grade > 2 [15].

Pain improvement and surgical outcome of knee HTO are highly be dependent on the accuracy of correction. Moreover, correct patient selection also is mandatory for good clinical outcome. The number of HTO has increased significantly in Mongolia, however, researchers are still debating about the impact of the severity of knee osteoarthritis on the overcome of HTO. We have previously studied preoperative, 2, 6, and 18 months postoperative clinical outcomes and radiographic results in Mongolian patients. Fifty one percent of the total subjects underwent lateral closing wedge high tibial osteotomy and the remained 49 % received medial opening - wedge technique. At 18 months after surgery, WBL was 57.1 % in closed wedge and 58.8 % in open wedge HTO [16]. On account of the combination of pre-operative Kellgren-Lawrence grade and surgery outcome used to evaluate more detailed survival rates in Mongolian patients, we herein report a middle term HTO outcome of the patients who underwent high tibial osteotomy with knee osteoarthritis from October 2019 to June 2020 at Joint Center of the First Central Hospital of Mongolia. The objective of our study is to report the mid-term results of HTO for knee osteoarthritis according to the Kellgren Lawrence classification.

Material and Methods

Study design and participants

We performed a clinical trial with repeated measurement to compare two different types of high tibial osteotomy (HTO) with medial opening-wedge or lateral closing-wedge technique for the primary knee osteoarthritis. Repeated measurements were done before surgery and second, sixth as well as twelve months after surgery. Participants were selected randomly in the study groups. Eligible patients were recruited from the Joint Center of the First Central Hospital of Mongolia with written consent. There were the following inclusion criteria: patients over 18 years and diagnosed with medial compartment osteoarthritis of the knee, diagnosed with 1 - 3 grades of osteoarthritis according to the Kellgren-Lawrence classification and varus deformity of the lower extremity. The criteria for exclusion in the study were: a previous history of any kind of surgical procedure around the knee, presence of knee instability, 4th grade osteoarthritis, participants refusing to enrolling in the study, diagnosed with severe chronic illness of other organs.

Sample size

We estimated the sample size of the interested population using the equation below which is appropriate to randomized clinical trial and belongs to a two-sided test.

$n = [(Z\alpha/2 + Z\beta)2 \times \{2(y)2\}] / (\mu1 - \mu2)$

$73 = [(1.96 + 0.84)2 \times \{2(1.83)2\}] / (0.85)$

n – sample size in one group

μ1 – The mean score in medial opening-wedge high tibial osteotomy

μ2 – The mean score in lateral closing-wedge high tibial osteotomy

μ1 - μ2 – clinically significance mean difference-0.852

y – standard deviation = 1.831

$Z\alpha$ / 2- significance level 5 % (1.96)

$Z\beta$ - power 80 % (0.84)

As stated in above, we proposed that a total of 160 patients with medial compartment osteoarthritis of the knee should be enrolled in the study and 80 study subjects should be assigned in each group. A total 22 study subjects couldn't meet inclusion criteria. Moreover 56 participants had insufficient information and dropped during follow up. 100 study subjects' data were finally analyzed.

Randomization and allocation concealment

A total of 100 study participants underwent high tibial osteotomy with knee osteoarthritis from October 2019 to June 2020 at the Joint Center of the First Central Hospital of Mongolia and gave permission to take part in the study. We generated a randomization code in each study subject to preserve blindness. Study participants were randomly assigned either to intervention or control groups by using a computer-generated randomization sequence.

Variable measurements

Outcome evaluation of the participants was accomplished at baseline, at 2 months, 6 months, 8 months and 18 months post-operatively. Prior to the operation, we collected patients' demographic data including participant age, sex, education level, cigarette and alcohol consumption, date of osteoarthritis diagnosis, nonsurgical management such as knee joint injection, physical therapy and pain killer medicines. Additionally, we obtained the Oxford knee score questionnaire and the Lysholm Knee Scoring Scale. Field researchers estimated participants' body mass index and determined the degree of knee joint flexion and extension range.

According to the classification of Kellgren and Lawrence, the grade of osteoarthritis was scored depending on the measurements, weight bearing line (WBL), and medial proximal tibial angle (MPTA) on standing long leg alignment radiograph. During pre-operative planning, we used the Miniaci method to calculate correction angle and gap in the weight bearing line which was adjusted on Fujisawa point. We assessed knee joint menisci, anterior and posterior cruciate ligaments, medial and lateral collateral ligaments, and hip joint cartilage using MRI of the knee.

At 2 months, 6 months, and 18 months following operation, post-operative complications were recorded and the Oxford knee score questionnaire and the Lysholm Knee Scoring Scale were obtained from the participants. The body mass index, knee joint range WBL and MPTA were measured.

The Lysholm Knee Scoring Scale is an 8-item patient reported instrument consisting of subscales for limp (5 scores), the need for support (5 scores), pain (25 scores), instability (25 scores), locking (15 scores), swelling (10 scores), squatting (5 scores) and stair climbing (10 scores). Scores range from 0 to 100.

The Oxford knee score is a 12-item self-reported

questionnaire and is scored from 0 to 48. Each item is measured from 0 to 4 (0 being the worst outcome and 4 being the best). The weight bearing line (WBL) is measured by a line from the center of femoral head to the center of the ankle joint. It is assigned 0 % at the most inner point of the tibia, and 100 % at the outside point of the tibia. Medial proximal tibial angle (MPTA) can be determined by laying a line alongside the tibial anatomical axis. Following it, another line should be laid to connect with the proximal portion of the tibia. Finally, medial proximal tibial angle is measured where the above mentioned two lines crossover by determining the angle between inner and proximity part of the tibia.

Field researchers estimated participants' body mass index and determined the degree of knee joint flexion and extension range.

Weight bearing line (WBL) and medial proximal tibial angle (MPTA) were calculated on standing long leg alignment radiograph. During pre-operative planning, we used the Miniaci method to calculate correction angle and gap in weight bearing line which was adjusted on Fujisawa point.

Kellgren Lawrence Classification of knee osteoarthritis

All participants were divided into the groups as diagnosed with Kellgren Lawrence (KL) classification. Table 1 illustrates grades of knee osteoarthritis and its description according to KL classification [13 - 14].

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 lower limb alignment following HTO is considered as 3^{o} to 5^{o} of valgus (i.e. angled towards the midline) from the mechanical axis 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 1). Figure 2 shows a comparison between the preoperative weight bearing line and the post - operative weight bearing line.

Medial proximal tibial angle calculation

A known complication of HTO is recurrence of varus deformity and this related to the medial proximal tibial angle which is 87^{0} (85^{0} - 90^{0}) normally. Previous studies have shown that the rate of recurrence of varus deformity is the lowest when the medial proximal tibial angle is corrected to 95^{o} and this was also an objective during HTO surgery (Figure 3).

Statistical analysis

We expressed continuous variables including body mass index, degree of axis correction, medial proximal tibial angle and knee joint flexion and extension range as the mean and standard deviation and assessed normal distributed data using the Kolmogorov-Smirnov test. Categorical data such as sex, education level and tobacco consumption were presented by frequencies and percentages. For categorical variables, Chi-square test was carried out. The main effects of time, treatment type and their interaction were determined using a mixed two-way ANOVA with a Greenhouse-Geiser adjustment for lack of sphericity. The repeated measurements within subjects were then compared to the previous time interval using paired t-tests. A Bonferroni-type correction was applied to all test results resulting in a significance level set at $p < 0.017$ ($p = 0.05/3$). Statistical analysis was performed using STATA 13.0 software.

Ethical statement

The study was approved by the Research Ethics Committee of the Mongolian National University of Medical Sciences on June 21, 2019 (No. 2019/6-21). All patients signed an informed consent form before clinical examination and morphometric measurement.

Results

Table 1 shows the Kellgren Lawrence classification of knee osteoarthritis. In Table 2, we show the general characteristics of participants. The mean age of study participants was 49.26 ± 9.14 and female male ratio was 9:1.

Table 1. Kellgren Lawrence classification of knee osteoarthritis.

Grade		Description
0	Normal	No pathological changes
1	Questionable	Doubtful narrowing of joint space and possible osteophytic lipping
2	Mild	Definite osteophytes and possible narrowing of joint space
3	Moderate	Moderate multiple osteophytes, definite narrowing of joint space, some sclerosis, and possible deformity of bone ends
4	Severe	Large osteophytes, marked narrowing of joint space, severe sclerosis, and definite deformity of bone ends

Table 2. General characteristics of study participants.

Variables	Grades				p-value
	First (n = 24) Mean ± SD	Second (n = 34) Mean ± SD	Third (n = 42) Mean ± SD	Total (n = 100) Mean ± SD	
Age, years	39.75 ± 9.44	50.32 ± 8.43	53.83 ± 4.38	49.26 ± 9.14	0.000
BMI, kg	26.31 ± 4.65	26.37 ± 3.58	27.15 ± 3.07	26.68 ± 3.66	0.324
Fracture gap	12.17 ± 1.34	13.33 ± 1.11	14.86 ± 1.14	13.76 ± 1.61	0.000
Operation time	84.79 ± 12.81	81.94 ± 16.77	83.85 ± 16.93	83.43 ± 15.87	0.907
Gender	N (%)	N (%)	N (%)	N (%)	
Male	3 (12.5)	4 (11.7)	3 (7.1)	10 (10.0)	
Female	21 (87.5)	30 (88.3)	39 (92.9)	90 (90.0)	
Marital status					
Unmarried	3 (12.5)	2 (5.9)	-	5 (5.0)	
Married	21 (87.5)	32 (94.1)	42 (100)	95 (95.0)	
Education					
Middle	5 (20.8)	16 (47.1)	25 (59.5)	46 (46.0)	0.009
Upper	19 (79.2)	18 (52.9)	17 (40.5)	54 (54.0)	
Occupation					
Office	18 (75.0)	16 (51.6)	23 (56.1)	57 (59.4)	0.184
Not office	6 (25.0)	15 (48.4)	18 (43.9)	39 (40.6)	

Table 3. Osteotomy side and fracture types.

Variables	Grades				p-value
	First (n = 24)	Second (n = 34)	Third (n = 42)	Total (n = 100)	
Group code	N (%)	N (%)	N (%)	N (%)	
Medial opening wedge	11 (45.8)	15 (44.1)	23 (54.8)	49 (49.0)	0.613
Lateral closing wedge	13 (54.2)	19 (55.9)	19 (45.2)	51 (51.0)	
Osteotomy side					
Above lateral	1 (8.3)	-	1 (4.3)	4 (8.0)	
Below	2 (16.7)	2 (13.3)	4 (17.4)	7 (14.0)	
Within lateral	7 (58.3)	1 (6.6)	17 (73.9)	36 (72.0)	
Within medial	2 (16.7)	12 (80.0)	1 (4.3)	3 (6.0)	

Continued

Osteotomy fracture type				
I	11 (91.7)	13 (86.7)	20 (90.9)	44 (89.7)
II	1 (8.3)	2 (13.3)	1 (4.5)	4 (8.2)
III	-	-	1 (4.5)	1 (2.0)

Among the socio-demographic characteristics, education was significantly associated with knee OA. There were 20.8 % of participants who had vocational school education in grade 1 and it was increased to 59.5 % in grade 3 OA. On the other hand, participants who hold higher education were lesser in grade 3 group than grade 1. As stated here, a total of 42 people with grade 3 of osteoarthritis underwent high tibial osteotomy and the operation rate was higher in these participants compared to people with first and second stage of osteoarthritis.

Mean duration of knee pain was 23 months and 22 months, in patients with medial opening-wedge and lateral closing-wedge high tibial osteotomy groups, respectively. Wedge osteotomy characteristics was shown in Table 3. Lateral closing was 54.2 % and 55.9 % in grade 1 and 2, respectively. On the other hand, medial opening in grade 3 was to some extent more than in the remaining 2 grades.

Table 4. Preoperative and postoperative weight bearing lines.

Variables	Grades				p-value
	First [a] (n = 24) Mean ± SD	Second [b] (n = 34) Mean ± SD	Third (n = 42) Mean ± SD	Total (n = 100) Mean ± SD	
PreWBL% [c]	25.61 ± 12.06	28.35 ± 10.06	11.43 ± 8.22	20.54 ± 12.57	0.000
Post2mWBL%	57.58 ± 2.39	57.94 ± 3.87	56.47 ± 4.08	57.24 ± 3.69	0.170
Post12mWBL% [d]	58.71 ± 3.29	59.26 ± 3.70	56.31 ± 4.52	57.89 ± 4.17	0.009

The mixed two-way ANOVA results: Interaction of time and treatment F (1.612, 337.59) = 21.151, p < 0.007; Main effect of time F (1.821, 436.41) = 345.31, p < 0.009; Main effect of treatment F(1,213 = 0.231, p = 0.121; Pairwise comparisons: [a]PreWBL vs. Post12mWBL, p = 0.031; [b]PreWBL vs. Post12mWBL, p = 0.021; Multiple comparisons: [c]First vs. Second, p = 0.001; [d]First vs. Third, p = 0.005. Pre WBL – preoperative weight bearing line; Post2mWBL – Postoperative 2 months weight bearing line; Post12mWBL – Postoperative 12 months weight bearing line.

Table 5. Preoperative and postoperative medial proximal tibial angles.

Variables	Grades				p-value
	First [a] (n = 24) Mean ± SD	Second [b] (n = 34) Mean ± SD	Third [c] (n = 42) Mean ± SD	Total (n = 100) Mean ± SD	
PreMPTA[d]	83.04 ± 2.29	82.06 ± 2.88	79.57 ± 4.12	81.25 ± 3.63	0.000
Post2mMPTA[e]	93.71 ± 2.74	93.35 ± 2.39	91.74 ± 2.59	92.76 ± 2.68	0.002
Post6mMPTA	93.17 ± 2.39	92.82 ± 2.48	92.09 ± 3.07	92.6 ± 2.73	0.108
Post12mMPTA[f]	93.75 ± 2.05	93.67 ± 2.16	91.64 ± 3.26	92.84 ± 2.82	0.001

The mixed two-way ANOVA results: Interaction of time and treatment F (1.631, 317.42) = 24.167, p < 0.009; Main effect of time F (1.831, 521.32) = 381.92, p < 0.008; Main effect of treatment F(1,728 = 0.347, p = 0.289; Pairwise comparisons: [a]PreMPTA vs. Post12mMPTA, p = 0.002; [b]PreMPTA vs. Post12mMPTA, p = 0.043; [c]Post2mMPTA vs. Post12mMPTA, p=0.051; Multiple comparisons: [d]First vs. Third, p = 0.002; [e]Second vs. Third, p = 0.008; [f]First vs. Third, p = 0.009. Pre MPTA – preoperative medial proximal tibial angle; Post2mMPTA – Postoperative 2 months medial proximal tibial angle; Post12mMPTA – Postoperative 12 months medial proximal tibial angle.

Table 6. Knee extension range of motion and moviments.

Variables	Grades First [a] (n = 24) Mean ± SD	Second (n = 34) Mean ± SD	Third (n = 42) Mean ± SD	Total (n = 100) Mean ± SD	p-value
PreExt [b, c]	1.96 ± 1.97	2.85 ± 2.38	3.55 ± 2.40	2.93 ± 2.36	0.008
Postext2m	15.71 ± 7.69	16.44 ± 8.14	15.14 ± 60.20	15.72 ± 7.21	0.677
Postext6m	3.29 ± 2.15	4.15 ± 2.73	3.92 ± 2.68	3.85 ± 2.57	0.417
Postext12m	2.50 ± 1.62	2.47 ± 1.97	3.19 ± 2.25	2.78 ± 2.03	0.138

The mixed two-way ANOVA results: Interaction of time and treatment F (1.821, 273.51) = 21.157, p < 0.001; Main effect of time F (1.714, 518.14) = 391.93, p < 0.051; Main effect of treatment F(1,848 = 0.417, p = 0.192; Pairwise comparisons: [a]PreExt vs. Postext2m, p = 0.051; Multiple comparisons: [b]First vs. Second, p = 0.089; [c]First vs. Third, p = 0.009. Pre Ext – preoperative knee extension range; Post2mExt – Postoperative 2 months knee extension range; Post6mExt – Postoperative 6months knee extension range; Post12mExt – Postoperative 12 months knee extension range.

Table 7. Knee flexion ranges by months.

Variables	Grades First [a] (n = 24) Mean ± SD	Second [b] (n = 34) Mean ± SD	Third [c] (n = 42) Mean ± SD	Total (n = 100) Mean ± SD	p-value
Preflex [d, e]	126.54 ± 11.30	114.0 ± 9.13	103.83 ± 9.52	112.74 ± 9.98	0.000
Postflex2m	77.54 ± 10.56	71.08 ± 9.58	74.31 ± 10.93	73.99 ± 10.58	0.394
Postflex6m [f]	118.71 ± 10.79	106.23 ± 10.55	99.01 ± 9.69	106.23 ± 12.74	0.000
Postflex12m [g]	125.87 ± 10.16	111.61 ± 9.95	103.40 ± 9.19	111.59 ± 13.03	0.000

The mixed two-way ANOVA results: Interaction of time and treatment F (1.734, 428.21) = 24.157, p < 0.008; Main effect of time F (1.834, 529.11) = 365.86, p < 0.043; Main effect of treatment F(1,715 = 0.526, p = 0.517; Pairwise comparisons: [a]Preflex vs. Postflex12m, p = 0.032; : [b]Preflex vs. Postflex6m, p = 0.000; [c]Preflex2m vs. Postflex6m, p = 0.000; Multiple comparisons: [d]First vs. Second, p = 0.089; [e]Second vs. Third, p = 0.009; [f]First vs. Third, p = 0.015; [g]First vs. Third, p = 0.000. Pre-Flex – preoperative knee flexion range; Post2mflex – Postoperative 2 months knee flexion range; Post6mflex – Postoperative 6months knee flexion range; Post12mflex – Postoperative 12 months knee flexion range.

Table 8. Oxford knee scores in patients with osteoarthritis of the knee.

Variables	Grades First [a] (n = 24) Mean ± SD	Second [b] (n = 34) Mean ± SD	Third [c] (n = 42) Mean ± SD	Total (n = 100) Mean ± SD	p-value
PreOxford [d]	33.58 ± 3.95	27.47 ± 23.71	23.71 ± 4.43	27.36 ± 33.58	0.000
PostOxford12m [e, f]	42.33 ± 2.48	38.97 ± 4.02	36.66 ± 5.15	38.81 ± 4.77	0.000

The mixed two-way ANOVA results: Interaction of time and treatment F (1.734, 428.21) = 24.157, p < 0.008; Main effect of time F (1.834, 529.11) = 365.86, p < 0.043; Main effect of treatment F (1,715 = 0.526, p = 0.517; Pairwise comparisons: [a]PreOxford vs. PostOxford12m, p = 0.001; [b]PreOxford vs. PostOxford12m, p = 0.003; [c]PreOxford vs. PostOxford, p = 0.008; Multiple comparisons: [d]First vs. Second, p = 0.071; [e]Second vs. Third, p = 0.001; [f]First vs. Third, p = 0.000. PreOxford – preoperative Oxford knee score; PostOxford12m – postoperative 12m Oxford Knee score

The weight bearing line (WBL) was 11.43 ± 8.22 preoperatively, and increased to 56.31 ± 4.52 after 12 months post-surgery in grade 3 (Table 4). The total WBL improved from 20.54 ± 12.57 to 57.24 ± 3.69 two months after surgery and 57.89 ± 4.17 after 12 months. Further, medial proximal tibial angle (MPTA) was shown in Table 5. All three grade groups improved after surgery. After 12 months, MPTA was 93.75 ± 2.05 in grade 1, 93.67 ± 2.16 in grade 2 and 91.64 ± 3.26 in

grade 3 group. According to the knee extension range, the mean value of preoperative knee extension range between grade groups, was statistically significant (p 0.008) (Table 6).

In Table 7, we shown Flexion range of the participants. Pre-surgery, range was 126.54 ± 11.30 in grade 1, 114.0 ± 9.13 in grade 2 and 103.83 ± 9.52 in grade 3 groups. 12 months follow-up resulted in 125.87 ± 10.16 in grade 1, 111.61 ± 9.95 in grade 2 and 103.40 ± 9.19 in grade 3 groups. Pre-operational, 6 and 12 month follow up was statistically significant. In Table 8, the Oxford knee sore is given. Compared to the pre-surgery score, grade 1 score increased to 42.33 ± 2.48, grade score 2 increased to 38.97 ± 4.02 and grade 3 score increased to 36.66 ± 5.15 after 12 months of surgery.

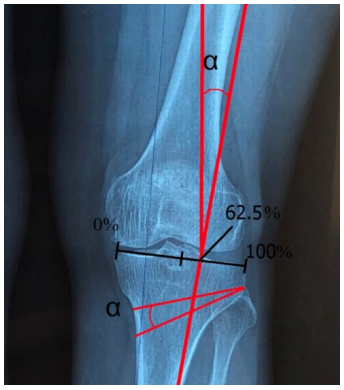

Figure 1. Fujisawa point is located 62.5% of the tibial plateau.

Figure 2. Pre- and post-operative weight bearing line.

A. B.

Figure 3. Pre-operative medial proximal tibial angle (A) was 84° for right, 82° for left and it corrected to 96° for right, 94° for left post operatively (B).

Discussion

Knee osteoarthritis is the most common joint disorder, most of which is accompanied by various deformities of the knee joint [15 - 17]. It has been demonstrated that there are currently approximately 355 million osteoarthritis patients worldwide. According to March et al. OA is the most common, incurring significant economic, social and psychological costs. Costs of illness have risen over recent decades accounting for up to 1 - 2.5 % of the gross national product for those countries studied so far, including the USA, Canada, the UK, France and Australia [18]. Nowadays, early knee OA can be managed by educational and exercise programs with the addition of appropriate pain relief medications. However, in the case of middle and late stages of knee OA, surgical treatments are primary.

There are three surgical methods for late stage OA: total knee arthroplasty (TKO), unicompartmental knee arthroplasty (UKA), and high tibial osteotomy (HTO). As described by Choi et al. patient satisfaction after TKA has been described as ranging from 75 % to 92 %. Based on a review of the Swedish Knee Arthroplasty Registry, 17 % of the patients were not satisfied with the outcome of TKA. The retrospective study of lateral UKA in China revealed, on the other hand, that following lateral UKA, postoperative outcomes were satisfactory in patients with lower ASA scores, diagnosis with primary OA, higher preoperative HSS scores and those with postoperative valgus alignment [19, 20]. HTO is a more conservative surgical procedure which has been used for over 60 years in clinical practice. A systematic review by He et al. included a total of 6555 eligible cases, comprised of 3351 open wedge HTO patients and 3204 closed wedge HTO patients. Regardless of whether the chosen procedure was open or closed, both HSS scores increased significantly compared to that in preoperative scores. Moreover, compared with closed wedge HTO, the height of the patella and tibial posterior slope angle increased following open wedge HTO. Additionally, open wedge HTO has a better long-term survival rate and lower

fracture rate [21 - 25].

Kellgren - Lawrence scale is widely used for a validation of hip and knee osteoarthritis nowadays as reference by the World Health Organizations. The pain improvement and surgical outcome of knee HTO are highly be dependent on the accuracy of correction. A retrospective study (twenty-one cases are grade 1 and 36 cases are grade 2) showed improved VAS score, Lysholm score, HSS score, and IKDC score at 3 months, 1 year after operation, and mMPTA and FTA were also significantly improved at last follow-up. When the internal fixator was removed, the arthroscopic re-assessment found that the cartilage regeneration was classified into 10 cases of grade 1 and 47 cases of grade 2; 18 cases of immature cartilage regeneration and 29 cases of mature cartilage regeneration were found in the knee joints of grade 2 cartilage regeneration [26 - 28]. Another retrospective study conducted by Li et al. demonstrated associations between different clinical factors and HTO survivorship. As a result, age, body mass index (BMI), preoperative Kellgren-Lawrence grade and preoperative VAS score were potential risk factors for HTO survivorship. The five-year HTO survivorship for the treatment of medial compartment osteoarthritis of the knee was approximately 85.4 %. Age > 60 years, BMI > 25.35 kg/m^2, preoperative Kellgren - Lawrence grade > 2 and preoperative VAS score > 5 are independent risk factors for early conversion to TKA in patients with HTO surgery [29, 30]. According to the retrospective study by Liu et al. short-term follow-up (17 knees of grade 2, 47 knees of grade 3, and 47 knees of grade 4) resulted with clinical outcomes of 51 knees in the satisfaction group and 77 knees in the significant improvement group. In functional outcomes, 43 knees were in the satisfaction group and 76 knees in the significant improvement group [25]. In our previous study, the clinical outcome and radiographic results were examined preoperatively, at 2, 6 and 18 months postoperatively. Fifty one percent of the total subjects underwent lateral closing wedge high tibial osteotomy and the remained 49 % received the medial opening-wedge technique. At 18 months after surgery, WBL was 57.1 ± 4.2 in closed wedge and 58.8 ± 4.0 in open wedge HTO, which is slightly higher than our present study. Further, MPTA also was measured. All three grade groups were improved after surgery. After 12 months, MPTA was 93.75 ± 2.05 in 1st grade, 93.67 ± 2.16 in 2nd grade and 91.64 ± 3.26 in 3rd grade. In our previous study, the value was 92.8 ± 2.7 in the lateral closing wedge osteotomy group and 92.8 ± 3.0 in the medial opening wedge osteotomy group. In the present study, we report the mid-term results of HTO for knee osteoarthritis by the Kellgren- Lawrence classification in Mongolian patients. A total of 100 patients participated in this study. The mean age of study participants was 49.26 ± 9.14 and female male ratio was 9:1. Lateral closing was 54.2% and 55.9% in 1st and 2nd grade, respectively. On the other hand, medial opening in 3rd grade was to some extent more than the remaining 2 grades. WBL was 11.43 ± 8.22 preoperatively, and increased to 56.31 ± 4.52 after 12 months post-surgery in 3rd grade. Matsushita et al. demonstrated that, within 55 patients who underwent HTO, mean WBL was 71.2 % ± 7.3 %, which is significantly higher than our study [22]. In the retrospective cohort study by Park et al. MPTA of patients with tibial varus deformity, a preoperative medial proximal tibial angle [MPTA of] < 85° was improved to 94.0° ± 2.6°, while in patients with tibia without varus deformity, preoperative MPTA ≥ 85°), MPTA score was 94.0° ± 2.6° [23]. This was similar to our present study.

Our study has some limitations. First, sample size was relatively small and study subjects were selected from a single institution. Also, follow-up time was too short thus the long-term post-operational outcomes could not be determined. Second, we have not assessed some surgical aspects as well as patient characteristics in this study. Several studies demonstrated that BMI and preoperative VAS scores could be the potential risk factors for HTO survivorship. Therefore, future studies determining these and other factors, and including patients from different hospitals would be helpful in overcoming the HTO surgical outcome challenges.

Conclusion

In the present study, patients with knee OA were divided into groups as diagnosed with Kellgren- Lawrence (KL) classification. Lateral closing wedge HTO was performed in 54.2 % and 55.9 % of patients in 1st and 2nd grade, respectively. On the other hand, medial opening wedge HTO was performed in 3rd grade patients compared to other grades. WBL was 11.43 ± 8.22 preoperatively, and increased to 56.31 ± 4.52 at 12 months after surgery in 3rd grade. The total WBL was improved from 20.54 ± 12.57 to 57.24 ± 3.69 after two months of surgery and 57.89 ± 4.17 after 12 months.

Conflict of Interest

The authors state no conflict of interest.

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