# Open-Wedge High Tibial Osteotomy in Varus Knee Osteoarthritis: A 5-Year Prospective Cohort Study

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***Background:*** *High tibial osteotomy (HTO) is an accepted procedure to correct the varus deformity to restore the mechanical axis, reduce pain and delay the need for arthroplasty, especially in young and active patients. Nowadays, the opening wedge HTO is preferable than the close one.*
***Objective:*** *To evaluate the clinical results and complications of medial compartment gonarthrosis treated with opening wedge HTO.*
***Material and Method:*** *The prospective cohort study of 45 knees in 40 consecutive patients (32 women, 8 men, 46-81 years) with medial compartment osteoarthritis of the knee underwent medial open-wedge HTO and TomoFix™ between February 2004 and February 2009 (average follow-up of 46.1 ± 11.5 months).*
***Results:*** *During the follow-up period, patients experienced significantly greater pain relief from baseline pain-intensity scores (all $p < 0.001$). The mean femorotibial angle (FTA) at the preoperative, 1-year and more than 2-year follow-up were 171.27 ± 9.41 degrees of varus, 182.91 ± 4.93 and 182.45 ± 5.74 degrees of valgus, in orderly.*
***Conclusion:*** *Medial opening wedge HTO with TomoFix™ provided intraoperative desirable correction and sufficient stabilization. Early mobilization, rehabilitation and maintenance of correction alignment until bony union occurred without instrument failure.*

***Keywords:*** *High tibial osteotomy, Open-wedge osteotomy, Varus knee, Medial unicompartmental osteoarthritis*

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High tibial osteotomy (HTO) has been widely accepted since the Coventry[1] who first reported favorable outcomes. It has become a well-established surgical treatment of medial unicompartmental knee osteoarthritis (OA). Its principle is to correct malalignment and unload the arthritis compartment to relieve symptoms and suppress the disease progression[2]. Results of HTO vary considerably with literature, however, most series report an overall success rate ranging from 80% to 90% of patients at 5 years follow-up[3-5]. In the analysis of these results, several authors have found that the success achieved through high tibial osteotomy has been directly related to the alignment and amount of femorotibial angular correction after the surgery[4-8]. However, with recent advances in arthroplasty and longer, more predictable survivorship (93% at 10 years)[9], HTO is now mainly performed in young and active patients[10]. In these patients, HTO is used to alleviate pain, permit unrestricted activity and delay the need for a total knee replacement[11,12]. Technical options for HTO include lateral closing wedge, medial opening wedge and dome osteotomy. The classic closing wedge HTO can be technically challenging with risks to the common peroneal nerve, detachment of lateral muscles, a fibular osteotomy, compartmental syndrome, delayed union or nonunion, instability, recurrent varus deformity and valgus overcorrection[13].

In addition, large corrections can cause an offset of the proximal tibia, which may compromise later placement of the tibial component of total knee arthroplasty (TKA). Thus the medial opening wedge HTO has been developed to avoid the muscle

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detachment. Moreover, the opening wedge HTO has the advantages of maintaining the bone stock and gradually precise correcting the deformity close to its origin, which may facilitate subsequent arthroplasty[14]. The opening wedge HTO is advocated to technically easier and fibular osteotomy is not required[15].

The authors conducted a prospective follow-up of patients with moderate to severe medial unicompartmental OA of the knee who underwent medial opening wedge HTO and evaluated the clinical outcomes and its complications.

## Material and Method

This study was approved by the Ethics Committee of the Medical Service Department, Bangkok Metropolitant Administration. Patients with the symptom of knee pain and visited the Orthopedic out patient clinic, Charoenkrung-Pracharak Hospital, in February 2004 were enrolled in the study after giving their written informed consent. They were prospectively followed-up until February 2009.

### *Inclusion and exclusion criteria*

All the knees examined had varus malalignment, at least 110° of flexion and not more than 20° degree of extension lag, symptoms of medial joint pain at least 6 months and radiographic sign of medial compartment OA. The patients were all active.

Exclusion criteria of the study were: presence of symptomatic OA of the lateral compartment, rheumatoid arthritis, bone-healing disorders, medial or lateral subluxation.

### *Preoperative assessment and planning*

Before operation, careful clinical examination must be taken to exclude any possible degeneration of the lateral compartment and to evaluate the stability of the knee. The subjective pain intensity was determined by means of a visual analogue scale (VAS) ranging from 0 to 10 (0 = no pain, 10 = unbearable pain). A goniometer was used to measure passive and active range of motion (ROM, in degrees). The Knee society scores (KSS) were calculated preoperatively and at the follow-up in order to assess movement, deformity and activity. In this score system, 100-85 points is excellent; 84-70 is good; 69-60 is fair and under 60 is considered bad.

The radiological documentation included standard knee radiographs, a standing anteroposterior (AP) and a lateral view. Grading of knee OA was scored according to Ahlback classification of femorotibial joint and the malalignment was assessed by mean of the femorotibial angle in standing AP view.

The amount of correction of the mechanical axis was guided by the stage of degenerative changes in the medial joint compartment. If relevant narrowing of the medial joint space was shown on the radiograph, the authors carried out an overcorrection according to the work of Fugisawa and coworkers[16]. The new weight-bearing line was shifted to at a point 62% of total width of the proximal tibia from medial to lateral. The operation of this study was performed under spinal or general anesthesia. Intravenous prophylactic antibiotics were applied.

### *Surgical technique*

The operative technique of opening wedge HTO described by Lobenhoffer and coworkers[17,18] was used.

### *Postoperative rehabilitation*

Postoperative rehabilitation included immediate active movement and physiotherapy. The patients were allowed to early walk with partial weight-bearing (5-10 Kgs) by using crutches at third day postoperatively. Whenever radiographs of the knee show the complete healing of the osteotomy and clinical stability signs, the full weight-bearing without crutches was allowed. No brace is required after surgery.

### *Statistical analysis*

Statistical analysis was performed using SPSS for Windows version 11.0 (SPSS Inc. Chicago, IL, USA). The data was given as mean values and in percentage. Preoperative and postoperative values (VAS and KSS) were compared statistically by mean of paired t-test. Statistical significance was set at the $p < 0.05$ level.

## Results

Forty-five opening wedge HTO were carried out on a total of 40 patients and these were conducted as a prospective follow-up. In the study group, there were 32 women and 8 men with a mean age of $60.8 \pm 7.7$ years (range 46-81 year) and follow-up records of 17.7 to 60.6 months ($46.1 \pm 11.5$ months on average). The comorbidities were found in 25 patients with hypertension, 3 with diabetes mellitus (DM) and 4 with both of hypertension and DM.

During the study period, all reviews of opening wedge osteotomies were done by the same surgeon. Patient demographics were shown in Table 1.

**Table 1.** Patient's demographic characteristics

| Characteristic | Value |
|---|---|
| Patients (knees) | 40 (45) |
| Gender (female : male) | 32:8 |
| Age: yrs | 60.8 (SD 7.8) |
| Follow-up (months) | 46.1 (SD 11.5) |
| Grading of OA (Ahlbäck radiological classification) | |
| Grade 1 | 9 (20.0 %) |
| Grade 2 | 11 (24.5%) |
| Grade 3 | 15 (33.3%) |
| Grade 4 | 6 (13.3%) |
| Grade 5 | 4 (8.9%) |

All of the patients were followed-up with an average of 46.1 ± 11.5 months (range, 17.7-60.6). All patients were followed-up until radiological bony union of the osteotomy had been documented. Delayed union was observed in one patient while no nonunion was found. All united within 6 months post-operatively. All patients were encouraged to start full weight-bearing after an average of 14.4 ± 3.7 weeks (range 10-23 weeks).

Clinical follow-up after osteotomy demonstrated that 39 of 45 knees (86.7%) achieved the active range of motion within 6-month follow-up.

The mean femorotibial angle at the pre-operative, 1-year and over 1-year follow-up were 171.27° (range, 140-179), 182.92° (range, 165-190) and 182.45° (range, 160-190) (Fig. 1), respectively. Obtainable mean correction angle was 11.73° (range 3-25°) and 11.45 (range 2-24°), respectively. Based on these results, it appeared to have no loss of correction in 45 osteotomies. During the follow-up period, 13 implants in 12 patients were removed. There were 3 total knee replacements in 3 patients at the time of follow-up because of the persistent of symptoms such as pain.

At the follow-up intervals: 3, 6 and 12 months and over 2-year, the patients have experienced significantly greater pain relief from baseline pain-intensity scores (p-value < 0.0001). The mean VAS, before opening wedge HTO and after 3, 6, 12 months and over 2- year period, post operatively, were 7.1 ± 1.9 (range 4-10), 3.5 ± 1.7 (range 0-7), 2.8 ± 2 (range 0-7), 1.7 ± 1.6 (range 0-6) and 1.5 ± 1.5 (range 0-6) (Fig. 2).

The mean KSS score improved from pre-operative 51.0 ± 10.8 (range, 20-68) to 78.6 ± 10.8 (range, 46-92) at the 1-year follow-up (p < 0.001) and sustained through the last follow-up (Fig. 3).

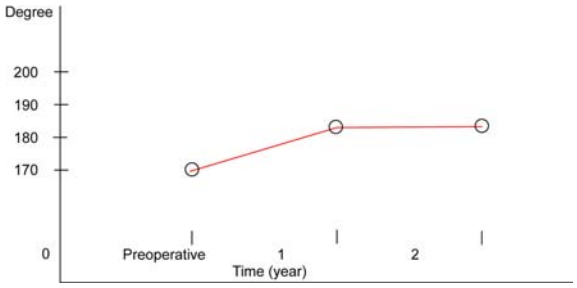


**Fig. 1** Femorotibial angle (FTA) measured from AP radiographs during the clinical course

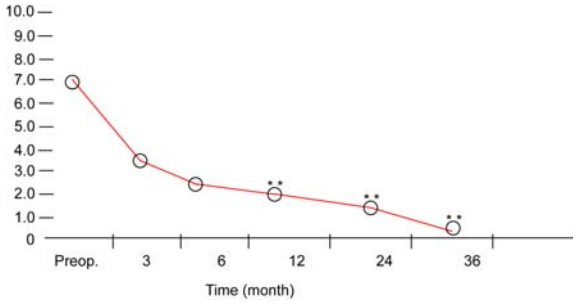


**Fig. 2** Clinical course of pain evaluating by visual analogue score (VAS)

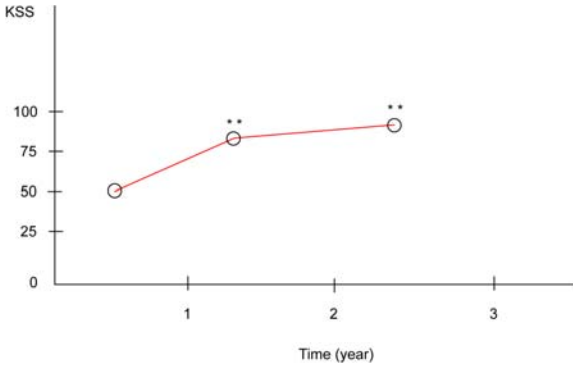


**Fig. 3** Knee society score (KSS) during the study period

Superficial incision wound infection was observed in 3 patients (3 knees) and was treated successfully with local wound care and parenteral antibiotic therapy. Vascular or neurological complication was not observed in this study.

## Discussion

The results showed that the opening wedge HTO achieved significantly accurate correction due

to the possible precise intraoperative position with a precise technique and fixation of TomoFix™ performing under fluoroscopic control[15]. In addition, it is easier to create an opening wedge than to remove a wedge of bone from proximal tibia[19]. If the failed correction occurs, it may be easier to insert a knee prosthesis later because of the correcting the deformity close to its source, no need to fibular osteotomy and the improvement in both coronal and sagittal planes deformities during the operation.

Clinically well selection of patient and surgical technique used in opening wedge high tibial osteotomy increase the success of the long-term results. Age of the patient, gender, range of motion, mediolateral and anteroposterior stability and the stage of arthritis should be carefully evaluated at preoperative period. In this study, 35 of 45 knees (77.8%) had Alhbäck grade 1-3 and 10 knees (22.2%) had grade 4-5 osteoarthritis (Table 1). Total knee arthroplasties were needed after opening wedge HTO in 1 knee with grade 4 and 2 knees with grade 5 after 2 years. The excellent and good results were achieved in patient aged less than 60 years with Ahlbäck grade 1-3 and the correction angle within 5°-12°.

The main effect of medial opening wedge HTO is mechanical. A slightly postoperative overcorrection of the mechanical axis prevents the recurrence of the deformity and revision surgery and provides better results in long term. Recent studies have been concluded that it is necessary to maintain a postoperative 2°-8° valgus angle for mechanical axis[16,18,20].

The tibiofemoral angle according to the anatomical axis was evaluated before and after the surgery. In the present study, the mean tibiofemoral angle at preoperative, 1-year and over 2-year postoperative were 171.27° varus, 182.91° and 182.45° valgus, respectively. It was detected that an average of 11.73° and 11.45° of valgus correction was obtained, regarding the preoperative values. These findings indicated that the corrected angle was maintained until the bony union occurred at the osteotomy site.

Partial vascular injury, intraarticular lateral tibial plateau fracture, lateral cortex fracture, subluxation, delayed union, nonunion, delayed wound healing, hematoma, superficial and deep wound infection, deep vein thrombosis, tibial slope changes, excessive correction, loss in the correction degrees, implant failure[22-24,26,28,29] and leg lengthening[30] were found as the common complications related to the medial opening wedge HTO. In the present study, we found two knees of intraarticular lateral tibial fracture (4.4%), 2 lateral tibial cortex fractures (4.4%), 1 delayed union (2.2%), 3 superficial wound infection (6.7%), 2 deep vein thrombosis (4.4%) and increasing leg length; average 1.2 cm (SD 0.5; range:1-2.5 cm). Lateral tibial plateau fracture was reported as 6.6%-14.6% during operation by Spahn[27], they also reported 16.4% implant insufficiencies out of Puddu plate. In our study, there was no implant failure and nonunion but we found only one patient (2.2%) with hypertension and uncontrolled diabetic delayed union.

To prevent any fracture in this area, the osteotomy should be almost to the lateral tibial cortex in order to act as hinge and gradually opening the wedge is obtained into plastic deformation zone[24].

Several studies have reported the successful short-term results of HTO in varus deformity and medial compartment osteoarthritis of knee. These results are deteriorated gradually on time. However, many studies have shown that the 5-year success rates were given as 80%-90%, whereas it has been decreased to 50%-65% after 10 years[3-5,9,22]. In our study, the obtained success rate was as 88.9% with the mean follow-up time of 46.1 $\pm$ 11.5 months.

In conclusion, the medial opening wedge HTO is the application that protects the joint, particularly in young and active patients with medial compartmental OA of knee with varus deformity. With this surgical procedure, a new technique and instrumental fixation system (TomoFix™) provides sufficient stabilization


**Fig. 4** A) preoperative ap radiography of a right knee with varus osteoarthritis, B) postoperative ap radiography after opening wedge valgus osteotomy performed with TomoFix™, C) photography of the patient showing varus deformity of a right knee, D) photography of the same patient at 1-year postoperatively with small transverse surgical scar, E) the patient with his right knee in flexion position

(Fig. 4). Rehabilitation and ambulation can start in the early postoperative period and maintenance of correction alignment until bony union occurs without instrument failure. The appropriate selection of patient, precise preoperative planning and meticulous execution of medial opening wedge HTO creates an opportunity for improvement in quality of life. This report showed that 88.9% of patients got postoperative activity reached to their preoperative activity with mild or no pain within 6-month period and sustained through the last follow-up.

**Disclosure**

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

**References**


1. Coventry MB. Osteotomy about the knee for degenerative and rheumatoid arthritis. J Bone Joint Surg Am 1973; 55: 23-48.
2. Coventry MB. Upper tibial osteotomy. Clin Orthop Relat Res 1984; (182): 46-52.
3. Vainionpaa S, Laike E, Kirves P, Tiusanen P. Tibial osteotomy for osteoarthritis of the knee. A five to ten-year follow-up study. J Bone Joint Surg Am 1981; 63: 938-46.
4. Insall JN, Joseph DM, Msika C. High tibial osteotomy for varus gonarthrosis. A long-term follow-up study. J Bone Joint Surg Am 1984; 66: 1040-8.
5. Coventry MB, Ilstrup DM, Wallrichs SL. Proximal tibial osteotomy. A critical long-term study of eighty-seven cases. J Bone Joint Surg Am 1993; 75: 196-201.
6. 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.
7. Matthews LS, Goldstein SA, Malvitz TA, Katz BP, Kaufer H. Proximal tibial osteotomy. Factors that influence the duration of satisfactory function. Clin Orthop Relat Res 1988; (229): 193-200.
8. Hernigou P. A 20-year follow-up study of internal gonarthrosis after tibial valgus osteotomy. Single versus repeated osteotomy. Rev Chir Orthop Reparatrice Appar Mot 1996; 82: 241-50.
9. Font-Rodriguez DE, Scuderi GR, Insall JN. Survivorship of cemented total knee arthroplasty. Clin Orthop Relat Res 1997; (345): 79-86.
10. Tigani D, Ferrari D, Trentani P, Barbanti-Brodano G, Trentani F. Patellar height after high tibial osteotomy. Int Orthop 2001; 24: 331-4.
11. Haslam P, Armstrong M, Geutjens G, Wilton TJ. Total knee arthroplasty after failed high tibial osteotomy long-term follow-up of matched groups. J Arthroplasty 2007; 22: 245-50.
12. Mont MA, Alexander N, Krackow KA, Hungerford DS. Total knee arthroplasty after failed high tibial osteotomy. Orthop Clin North Am 1994; 25: 515-25.
13. Coventry MB. Upper tibial osteotomy for osteoarthritis. J Bone Joint Surg Am 1985; 67: 1136-40.
14. Weale AE, Lee AS, MacEachern AG. High tibial osteotomy using a dynamic axial external fixator. Clin Orthop Relat Res 2001; (382): 154-67.
15. Lobenhoffer P, Agneskirchner JD. Improvements in surgical technique of valgus high tibial osteotomy. Knee Surg Sports Traumatol Arthrosc 2003; 11: 132-8.
16. 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: 585-608.
17. Lobenhoffer P, De Simoni C, Staubli AE. Open-wedge high-tibial osteotomy with rigid plate fixation. Tech Knee Surg 2002; 1: 93-105.
18. Staubli AE, De Simoni C, Babst R, Lobenhoffer P. TomoFix: a new LCP-concept for open wedge osteotomy of the medial proximal tibia - early results in 92 cases. Injury 2003; 34 (Suppl 2): B55-62.
19. Brouwer RW, Bierma-Zeinstra SM, van Raaij TM, Verhaar JA. Osteotomy for medial compartment arthritis of the knee using a closing wedge or an opening wedge controlled by a Puddu plate. A one-year randomised, controlled study. J Bone Joint Surg Br 2006; 88: 1454-9.
20. Franco V, Cerullo G, Cipolla M, Gianni E, Puddu G. Open wedge high tibial osteotomy. Tech Knee Surg 2002; 1: 43-53.
21. Magyar G, Ahl TL, Vibe P, Toksvig-Larsen S, Lindstrand A. Open-wedge osteotomy by hemi-callotasis or the closed-wedge technique for osteoarthritis of the knee. A randomised study of 50 operations. J Bone Joint Surg Br 1999; 81: 444-8.
22. Hernigou P, Ma W. Open wedge tibial osteotomy with acrylic bone cement as bone substitute. Knee 2001; 8: 103-10.
23. Klinger HM, Lorenz F, H□rer T. Open wedge tibial osteotomy by hemicallotasis for medial compartment osteoarthritis. Arch Orthop Trauma Surg 2001; 121: 245-7.

24. Naudie DD, Amendola A, Fowler PJ. Opening wedge high tibial osteotomy for symptomatic hyperextension-varus thrust. Am J Sports Med 2004; 32: 60-70.
25. Paccola CA, Fogagnolo F. Open-wedge high tibial osteotomy: a technical trick to avoid loss of reduction of the opposite cortex. Knee Surg Sports Traumatol Arthrosc 2005; 13: 19-22.
26. Koshino T, Murase T, Saito T. Medial opening-wedge high tibial osteotomy with use of porous hydroxyapatite to treat medial compartment osteoarthritis of the knee. J Bone Joint Surg Am 2003; 85-A: 78-85.
27. Spahn G. Complications in high tibial (medial opening wedge) osteotomy. Arch Orthop Trauma Surg 2004; 124: 649-53.
28. Naudie D, Bourne RB, Rorabeck CH, Bourne TJ. The Install Award. Survivorship of the high tibial valgus osteotomy. A 10- to -22-year followup study. Clin Orthop Relat Res 1999; (367): 18-27.
29. Esenkaya I, Elmali N. Proximal tibia medial open-wedge osteotomy using plates with wedges: early results in 58 cases. Knee Surg Sports Traumatol Arthrosc 2006; 14: 955-61.
30. Niemeyer P, Koestler W, Kaehny C, Kreuz PC, Brooks CJ, Strohm PC, et al. Two-year results of open-wedge high tibial osteotomy with fixation by medial plate fixator for medial compartment arthritis with varus malalignment of the knee. Arthroscopy 2008; 24: 796-804.

## *การตัดแต่งกระดูกหน้าแข้งส่วนต้นแบบเปิดอ้าในผู้ป่วยข้อเข่าเสื่อมร่วมกับภาวะเข่าโก่ง: การติดตามผลการรักษา 5 ปี*

***บรรเทิง พงศ์สร้อยเพชร, ชัยชนะ ตันติกุล***

***ภูมิหลัง:*** *การตัดแต่งกระดูกหน้าแข้งส่วนต้นได้รับการยอมรับว่าเป็นวิธีการแก้ไขภาวะเข่าโก่ง ซึ่งส่งผลทำให้น้ำหนักตัวกลับมาอยู่ในแนวเชิงกลของขา ลดอาการปวดและชะลอความต้องการผ่าตัดเปลี่ยนรข้อเข่าเทียม โดยเฉพาะในผู้ป่วยที่อายุน้อยและอยู่ในวัยทำงาน ปัจจุบันการตัดแต่งกระดูกหน้าแข้งส่วนต้นแบบเปิดอ้าเป็นที่นิยมมากกว่าแบบปิด*

***วัตถุประสงค์:*** *เพื่อศึกษาการดำเนินโรคและภาวะแทรกซ้อนในผู้ป่วยข้อเข่าเสื่อมร่วมกับภาวะเข่าโก่งที่ได้รับการตัดแต่งกระดูกหน้าแข้งส่วนต้นแบบเปิดอ้า*

***วัสดุและวิธีการ:*** *ทำการศึกษาในผู้ป่วย 40 ราย (หญิง 32 ราย ชาย 8 ราย มีอายุ 46-81 ปี) ที่มีภาวะข้อเข่าเสื่อมร่วมกับภาวะเข่าโก่งจำนวน 45 ข้อ ผู้ป่วยได้รับการตัดแต่งกระดูกหน้าแข้งส่วนต้นแบบเปิดอ้าและยึดตามด้วยโลหะชนิด TomoFix™ ระหว่างเดือนกุมภาพันธ์ พ.ศ. 2547-กุมภาพันธ์ พ.ศ. 2552*

***ผลการศึกษา:*** *ระยะการติดตามเฉลี่ยอยู่ที่ 46.10 ± 11.5 เดือน ในช่วงที่ทำการติดตามผลการรักษาในผู้ป่วย พบว่าผู้ป่วยอาการปวดเข่าที่ลดลงอย่างมีนัยสำคัญ (p-value < 0.001) ในขณะที่ค่าเฉลี่ยมุมระหว่างแกนกระดูกต้นขากับแกนกระดูกหน้าแข้งก่อนรับการผ่าตัดเท่ากับ 171.27 ± 9.41 องศา และค่าเฉลี่ยหลังได้รับการผ่าตัดแก้ไขเป็น 182.91 ± 4.93 และ 182.45 ± 5.74 องศา ทั้งนี้เมื่อทำการติดตามผู้ป่วยเป็นระยะเวลา 1 ปีและมากกว่า 2 ปี พบว่ามุมที่ได้รับการแก้ไขมีค่าเฉลี่ยเท่ากับ 11.73 ± 6.15 และ 11.45 ± 5.84 องศา ตามลำดับ*

***สรุป:*** *การตัดกระดูกหน้าแข้งส่วนต้นแบบเปิดอ้าและยึดตามด้วยโลหะชนิด TomoFix™ ในผู้ป่วยข้อเข่าเสื่อมร่วมกับภาวะเข่าโก่ง สามารถลดอาการปวดเข่า แก้ไขภาวะเข่าโก่ง ให้ความมั่นคงและคงรูปร่างหลังแก้ไขไว้ได้จนกระดูกที่ตัดแต่งติด นอกจากนี้ผู้ป่วยไม่จำเป็นต้องเข้าเฝือกขา ตลอดจนสามารถเคลื่อนไหวข้อเข่าและฟื้นฟูสมรรถภาพขาหลังการผ่าตัดได้อย่างรวดเร็ว*