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잠김금속판을 이용한 내측 개방성 근위경골절골술에서 안정성에 영향을 미치는 요인: 사체연구

Factors Affecting Stability after Medial Opening Wedge High Tibial Osteotomy using Locking Plate: A cadaveric Study

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서울대학교 대학원
의학과 정형외과학 전공
나 영 곤

A thesis of the Degree of Doctor of Philosophy

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February 2020

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Factors Affecting Stability after Medial Opening Wedge High Tibial Osteotomy using Locking Plate: A cadaveric Study

by
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Approved by Thesis Committee:

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Abstract

Factors Affecting Stability after Medial Opening Wedge High Tibial Osteotomy using Locking Plate: A cadaveric Study

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Purpose: Several factors may affect the stability after medial opening wedge high tibial osteotomy (MOW HTO) using a locking plate. We investigated the effect of screw-length, lateral hinge fracture and gap filling on the stability after MOW HTO using a locking plate.

Materials and methods: We randomly allocated 40 tibiae from fresh-frozen cadavers into five groups. Group A was fixated bicortically, while group B and C were fixated unicortically: 90% and 55% of drilled tunnel length, respectively. Group D was fixated using 90% length-screws with the lateral hinge fractured. Group E was fixated using 90% length-screws with gap filling using a bone substitute. Operated tibiae were tested under the axial compressive load using a material testing machine. The medial gap changes under the serial axial load of 100 to 600N and ultimate failure load was measured.

Results: Group D showed the biggest medial gap change and lowest failure load, while group E presented the smallest gap change and highest failure load. The medial gap change tended to increase with shorter screw length, but the difference was not significant between groups A, B, and C. Group C and D showed greater medial gap change and lower failure load compared to group E, while not differing from group A and B.

Conclusion: Unicortical fixation in proximal screw holes of a locking plate was not inferior to the bicortical fixation regarding axial stability in MOW HTO, although proximal screws that are too short should be avoided. Lateral hinge fracture decrease, while gap filling with bone substitute increase the axial stability. These findings should be considered during MOW HTO to achieve satisfactory stability.

Key words: Osteoarthritis, Knee, Tibia, Osteotomy, Locking plate, Stability, Lateral hinge fracture

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INTRODUCTION

Since high tibial osteotomy (HTO) was introduced in 1960's, it has been an established surgical treatment for relatively young and active patients with medial compartment osteoarthritis of the knee and varus deformity (1-4). Realignment of the lower extremity through HTO shifts the loading on the knee joint, from medial arthritic lesion to the intact lateral compartment, consequently, relieves the symptom and prevents progression of osteoarthritis (1,5). As loading on the joint is substantially affected by the limb alignment, achievement of optimal alignment is the key factor for the successful outcome of the HTO (5,6). In addition, initially achieved well-corrected alignment should be maintained until the secure bone union in the osteotomy site is completed. Loss of correction and nonunion are important complications of HTO which deteriorate the clinical outcome of the HTO (7). Therefore, whether sufficient mechanical stability is achieved is one of the most important issues of the HTO.

HTO is performed most often by either lateral closing wedge (LCW) or medial opening wedge (MOW) HTO (8,9). Historically, LCW HTO was more popular, as direct bone to bone contact of LCW HTO is advantageous in earlier bone healing and allows earlier weight bearing compared to MOW HTO, which creates a bony gap and frequently requires bone graft or void filling (8,10). To prevent correction loss and nonunion of the osteotomy site after MOW HTO, sufficient stability should be provided by the fixation device. After the introduction of the locking plate system that provides satisfactory mechanical stability (11,12), MOW HTO is gaining popularity (9). As optimal fixative is a prerequisite for favorable outcomes of MOW HTO, development of new superior implants is ongoing, especially focusing on biomechanical fixation strength (13-19). Majority of the previous biomechanical studies have attempted to find out the better fixative by comparing the different plate systems (13-19).

However, several factors may affect the stability after MOW HTO using a locking plate, such as the length of the screws (20), the integrity of lateral hinge (21-23), and gap filling (24-29). While many biomechanical studies of HTO compared the stability of different fixation devices (13-15,17-19,30,31), there is limited evidence regarding these specific issues in a same plate system. Owing to the concern over neurovascular injury, many surgeons prefer unicortical fixation on the proximal screw holes of locking plate (32). In several biomechanical studies, the proximal screws were fixed bicortically (15,18,25), while other did not comment on the length of the screws (19). One study reported superior stability of bicortical fixation in a bicondylar tibial fracture model (20), so whether the unicortical fixation of proximal screws provides sufficient biomechanical strength in MOW HTO is uncertain.

Unintended opposite side cortical fracture of the lateral hinge may occur during MOW HTO (21,33-36). Tekeuchi et al. classified the lateral hinge fracture into three type: type I, the fracture reaches just proximal to or within the tibiofibular joint; type II, the fracture reaches the distal portion of the proximal tibiofibular joint; and type III, a lateral plateau fracture (21). Several clinical studies reported the risk of lateral cortex fracture and correction loss, delayed union or nonunion, and reoperation (21-23). The incidence of lateral hinge fracture is upto 27.5% on the computed tomography (CT) scan and tends to be underestimated on the plain radiograph (37-39). Given the substantial incidence of the lateral hinge fracture, its biomechanical effect is important factor to be considered, whereas it is rarely reported yet (40). In addition, there is a controversy regarding the osteotomy gap management: leaving vacant or filling the defect with autograft, allograft or bone substitute (24,41,42). Bone union rates according to the gap filling methods have been reported well in the literature (24,43), but the effect of the bone substitute on the initial axial stability has not been sufficiently investigated (25).

We investigated the effect of screw-length, lateral hinge fracture and gap filling on stability after MOW HTO using a locking plate. We hypothesized that unicortical fixation using 90% length of tunnel length would not be inferior to bicortical fixation, while screws that are too short (55% of drilled tunnel length) would provide unsatisfactory axial stability. We also hypothesized that the lateral hinge fracture would reduce mechanical stability, whereas gap filling with bone substitute would reinforce it.

MATERIALS AND METHODS

Study design & specimen selection

This was an in vitro cadaver study. The approval of the ethical committee was waived by the institutional review board of our institution, because it did not involve human subjects. Initially, 25 cadavers were assessed for eligibility. CT scan was performed in the proximal tibiae of all cadavers to screen out osteoporotic bones, as bone density may affect the mechanical strength significantly. As the Hounsfield unit (HU) is a good indicator of bone density, we measured the HU of the region of interest (ROI) in the trabecular region of the proximal tibiae (44,45). Four cadavers were excluded because the HU value of the trabecular region of the proximal tibiae were less than 50HU, far less than the cutoff value of osteoporosis of lumbar spine or humeral head (44). Forty tibiae from 21 fresh-frozen cadavers were harvested without fibulae and soft tissue attached. Two knees were excluded as they were replaced with implants, leaving 40 tibiae for the final experiment.

Experimental groups

We randomly allocated the harvested tibiae into five groups using a computer-generated randomization table. A single surgeon performed all surgical procedures. MOW HTO was performed with uniplanar osteotomy and fixated using a locking plate (TomoFix®, DePuy Synthes, West Chester, PA, USA) and 5.0 mm selftapping locking screws. The osteotomy started from the medial metaphysis, 4 cm below the joint line, and progressed obliquely to the upper point of proximal tibiofibular joint, approximately 1.5cm below the joint line. All of the opened medial gaps were targeted at 10mm and maintained using laminar spreader until the final fixation. The locking plate was applied to the best fitting position of the medial proximal tibia, typically 1 cm below the plateau. All screw holes were drilled full length to penetrate the far cortex using a locking drill sleeve, and the drilled tunnel length was measured. There was no difference in the demographics, tibial plateau size and drilled tunnel length among the groups (Table 1).

The five groups were treated differently in terms of length of the proximal screws, the integrity of lateral hinge (intact or fracture), and gap filling with bone substitute (Table 1). Group A was fixated bicortically without gap filling, while group B and C were fixated using shorter screws without gap filling: 90% and 55% of drilled tunnel length, respectively (Figure 1A). We defined Group B as the standard group, representing the most typical clinical setting. Group D was fixated using 90% length-screws without gap filling, while the lateral hinge was fractured (Figure 2A). The lateral hinge fracture of the group D represents the type I according to the Takeuchi classification, which means the fracture line involves an extension of the osteotomy line and is just proximal to or within the tibiofibular joint (21). The plate fixation was performed while the fractured lateral hinge was tightened using two towel clips (Figure 2B). The lateral hinge was intact in the other groups. Group E was fixated using 90% length-screws with gap filling using bone substitute (geneX®; Biocomposites Ltd., Staffordshire, UK) (Figure 1B). The bone substitute contains β - tricalcium phosphate and calcium sulphate in a weight ratio of 1:1 (46). The distal screws were fixated bicortically, except the most distal screw that was fixated unicortically with identical length of 20 mm.

We addressed the hypotheses of this study by comparing each group with group B, the standard group: effect of the screw length (B *vs.* A, C), lateral hinge fracture (B *vs.* D), and gap filling with bone substitute (B *vs.* E).

Table 1. Demographics and group treatments

Group	A	B	C	D	E	P value
Demographics						
Age (years)	71.0 (7.3)	72.0 (4.9)	74.3 (5.0)	75.3 (5.8)	75.3 (5.7)	0.312
Sex: men	7 (88%)	6 (75%)	5 (63%)	6 (75%)	5 (63%)	0.926
Side: right	3 (38%)	5 (63%)	3 (38%)	5 (63%)	4 (50%)	0.832
Group treatments						
Proximal screw length / drilled tunnel length	>100%	90%	55%	90%	90%	
Lateral hinge	Intact	Intact	Intact	Fracture	Intact	
Gap filling	No	No	No	No	Yes	

* Ages are presented with mean age with standard deviation in the parenthesis.

Figure 1. Gap management for the defect on the osteotomy site

The bone defect created by the widening of the osteotomy site were either left vacant (1-A; group A, B, C, D) or filled with bone substitute (1-B; group E).

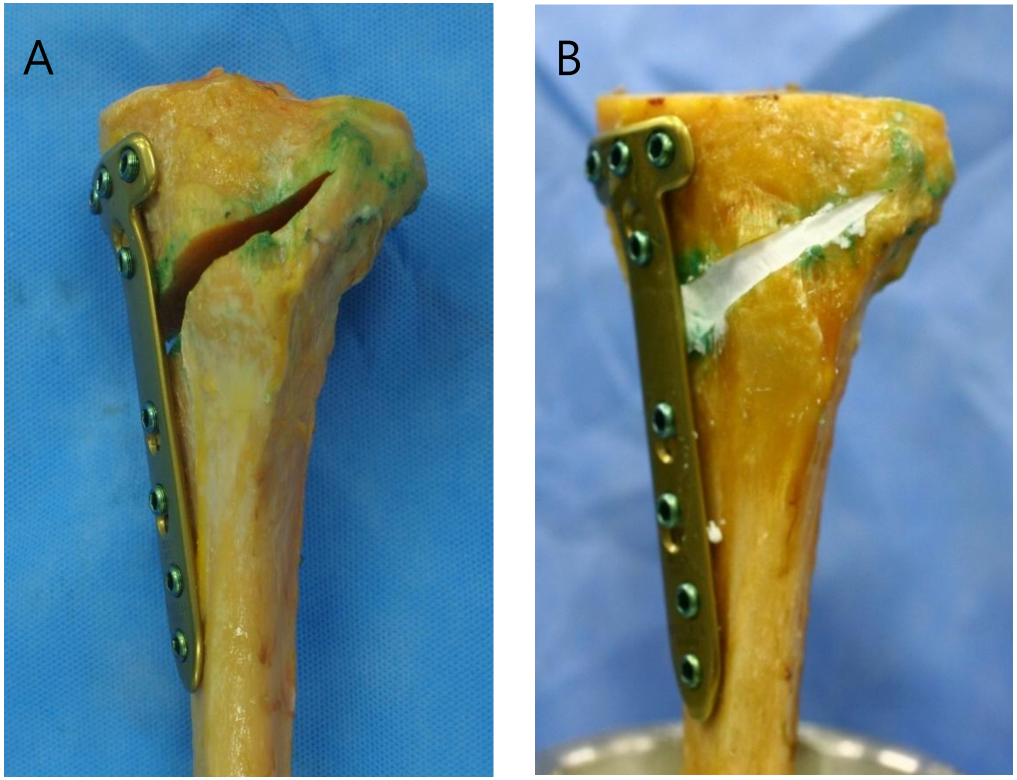
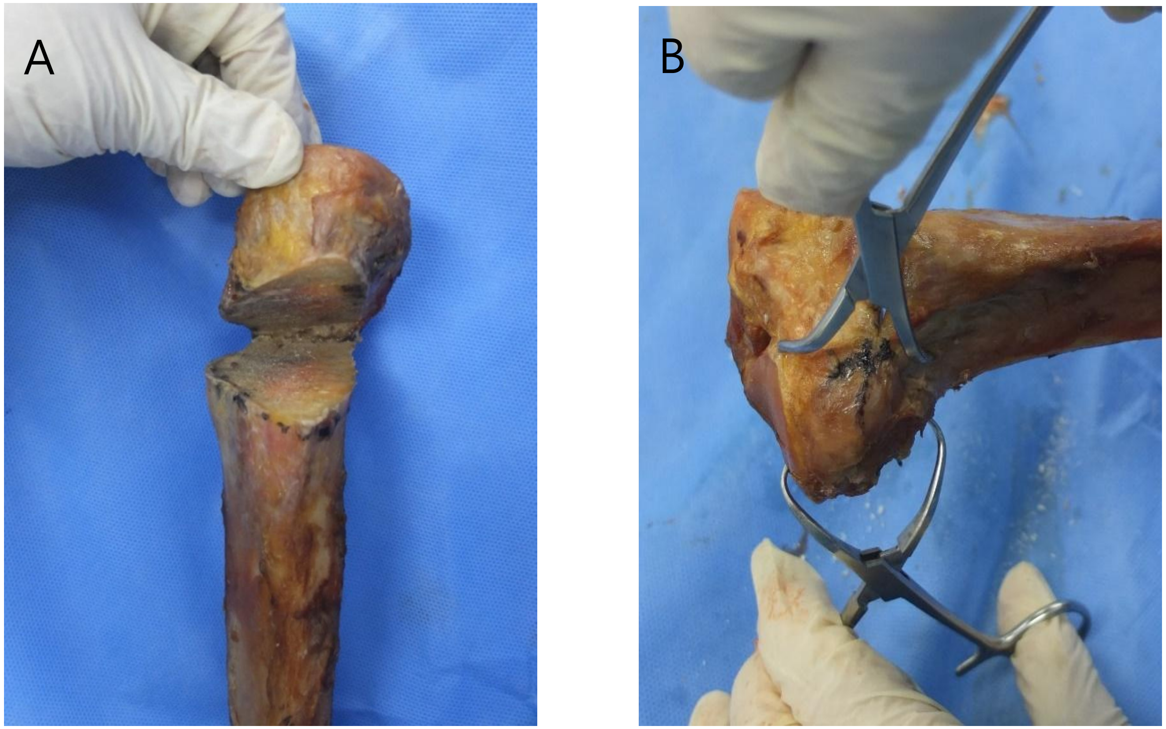


Figure 2. A sample specimen with lateral hinge fracture

The complete osteotomy was performed in the group D, to mimic the lateral hinge fracture (A). The plate fixation was performed while the fractured lateral hinge was tightened using two towel clips (B).



Biomechanical test set-up

The distal portion of the tibiae was molded in a cylindrical metal bowl using polymethyl methacrylate (PMMA) and consolidated for 12 hours in room air. The upper surface of the tibial plateau was flattened for full surface contact with a custom-made upper jig during the following biomechanical test. After solid consolidation was completed, the specimens were stored at -20°C until required and thawed at room temperature for 24 hours before experiments.

Biomechanical tests were performed using the Instron® universal test machine (model No. 5567, Instron, MA, USA), which has a position accuracy of 0.02 mm and a loading accuracy of 0.1 N. The test machine is dual column, table-top load frames, which is capable of various type of tests, such as tensile, compression and limited cyclic test (47). The load capacity is 30kN and the range of load application rate is from 0.001 to 500 mm/min. The cylindrical stainless bowl in which the specimens were embedded was mounted on the Instron® universal test machine, and the custom-made upper jig was applied to the flattened upper surface of the tibiae. The target point where the weight bearing line, which connects the center of the femoral head and the ankle center, passes the tibial plateau is various according to the operators, but typically about 62% of the mediolateral width of the tibia plateau (medial end = 0% and lateral end =100%) (32,48). In order to mimic the typical clinical setting, the compression loading axis was targeted to the center of the anteroposterior dimension and 62% of the mediolateral width of the tibial plateau with vertical direction to the ground in all specimens.

Biomechanical test protocol

Each specimen was subjected to three steps of biomechanical tests. First, cyclic loading tests were conducted with low load of 10 to 200 N as preconditioning (Figure 3). After 60 cycles of loading, any failure during the cyclic loading test was recorded. Second, medial gap change was measured under serial axial compression load of 100, 200, 300, 400, 500 and 600 N, using an electronic internal caliper gauge (Model No. 54-554-622, Fowler Co., Newton, MA, USA) with a resolution of 0.0127mm and accuracy of 0.02032mm (Figure 4). Third, a load to failure test was applied by increasing the axial compression force. The ultimate failure load, defined as the point at which the first reduction in loading occurs in the load-displacement curve (Figure 5), and the mode of failure were recorded. The testing machine was operated at a constant speed of 20 mm/min for all tests.

Figure 3. Change of specimen length after cyclic load test

Compressive extension is defined as the location of the crosshead/actuator of the test machine relative to the point where the gauge length is reset, which means the strain of the specimen under compressive force.

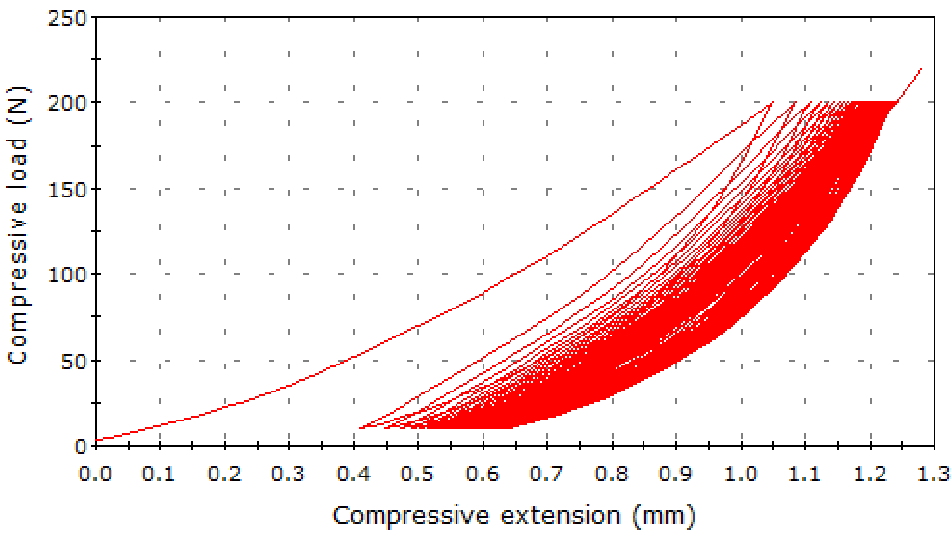


Figure 4. Biomechanical test setup for the medial gap measurement under serial axial compression load

Electronic internal caliper gauge was inserted into the medial gap of osteotomy site, just posterior to the plate with contact to the inner cortex of the medial border.

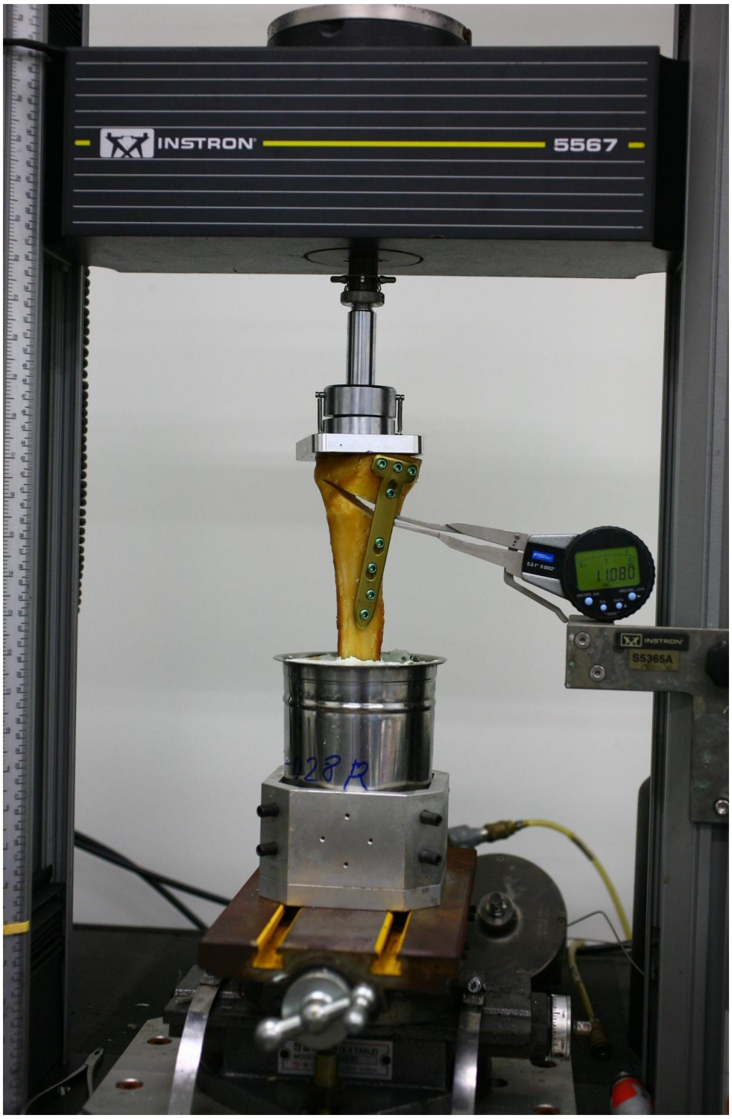
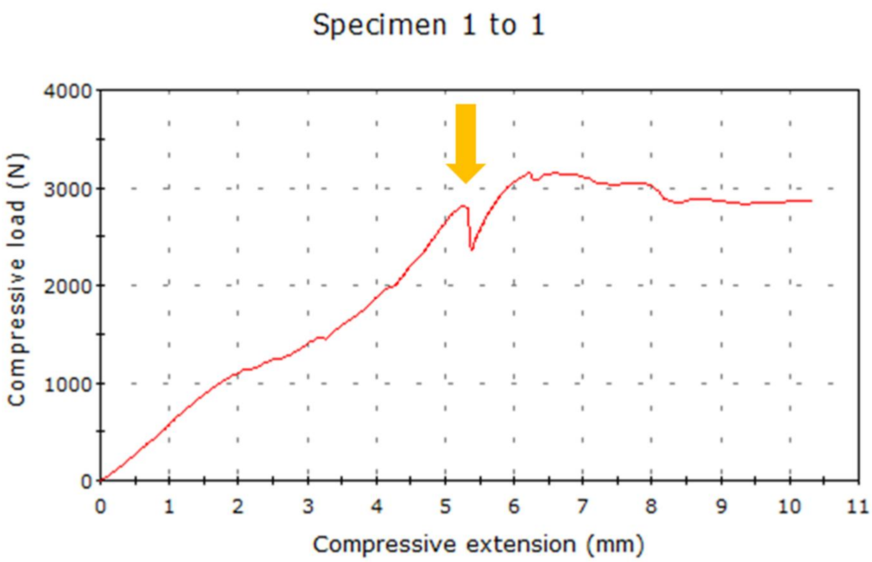


Figure 5. The definition of the ultimate failure load

Ultimate failure load which was defined as the point at which the first reduction in loading occurs in the load-displacement curve (yellow arrow). Compressive extension is defined as the location of the crosshead/actuator of the test machine relative to the point where the gauge length is reset, which means the strain of the specimen under compressive force.



Statistical analysis

All statistical analyses were performed using SPSS (IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY, USA). Null hypotheses of no difference were rejected if p-values were less than 0.05. Medial gap change under serial axial load, ultimate failure load, and mode of failure were compared. Inter-group differences were tested using Kruskal-Wallis test with Mann-Whitney U test (Bonferroni correction) as the post-hoc test for the continuous variables, while Chi-square/Fisher's test was applied on non-parametric categorical variables.

RESULTS

Cyclic loading tests

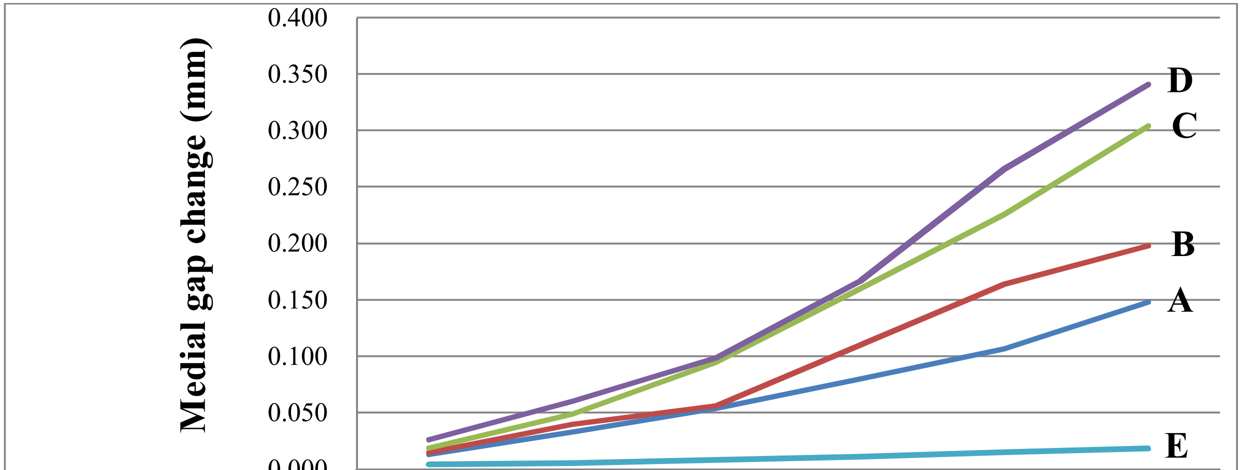
All specimens in each group tolerated 60 cycles of axial cyclic loading of 10 N to 200 N without failure. Therefore, all specimens were subjected to the following steps of biomechanical tests.

Medial gap changes under serial axial load

The medial gap changes increased as the axial load increased, and the gap in group E changed the least among the five groups (Figure 6). In the post-hoc test, the group E medial gap changed less than every other group under 300, 400, 500, and 600 N. The group C and D gap changes were greater than group E even under lower loading: 100, 200 and 300 N for the group C; 200 and 300 N for group D. There was no difference in the medial gap change between other group pairs.

Figure 6. Serial medial gap changes according to the axial load

Fx: fracture

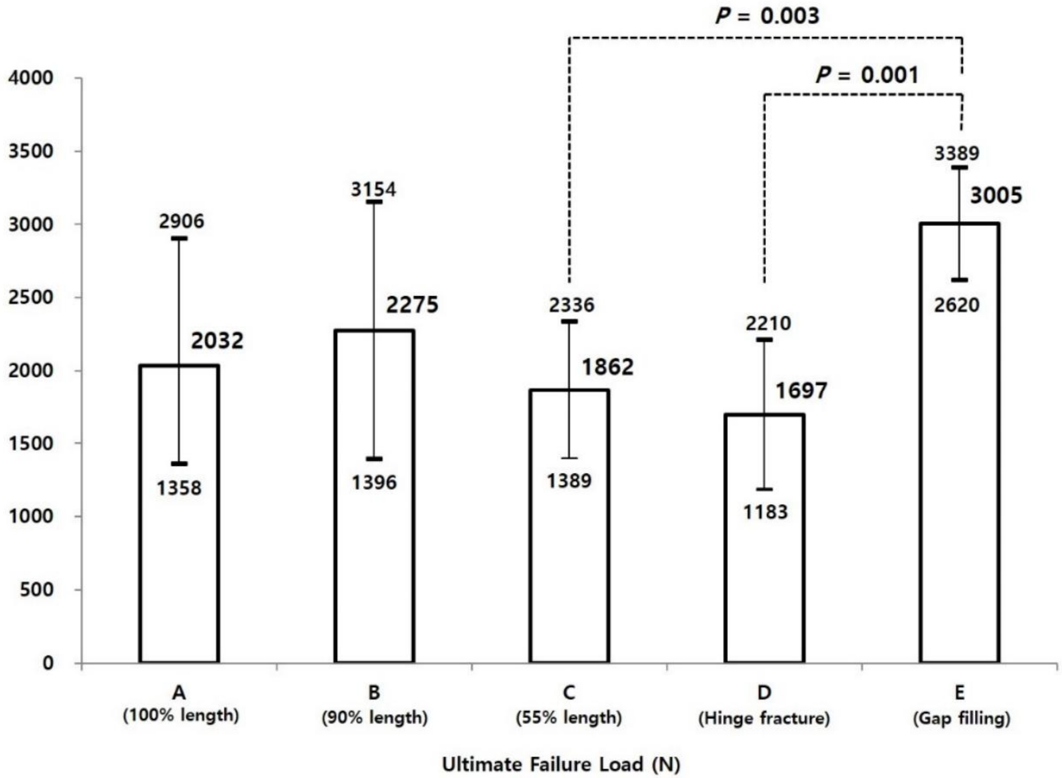


	100N	200N	300N	400N	500N	600N
A (100% screw length)	0.013	0.033	0.054	0.080	0.107	0.148
B (90% screw length)	0.015	0.040	0.056	0.110	0.164	0.198
C (55% screw length)	0.019	0.049	0.095	0.160	0.226	0.304
D (90% + Hinge Fx)	0.026	0.060	0.099	0.167	0.266	0.341
E (90% + Gap filling)	0.004	0.005	0.008	0.011	0.015	0.018

Load to failure test

The failure load was highest in the group E among the five groups ($p = 0.027$) (Figure 7). In the post-hoc test, the failure load of group E was higher than that of group C (3005 N vs. 1862 N, $p = 0.003$) and group D (3005 N vs. 1697 N, $p = 0.001$). There was no difference in comparison of all other pairs of groups. Interestingly, the group A showed lower failure load than group B, but the difference was not significant (2032 N vs. 2275 N, $p = 1.000$).

Figure 7. Comparison of the ultimate failure loads (presented as mean values with 95% confidence interval)



Mode of failure

All failures during the load to failure test under axial compression load resulted in fracture at the lateral cortex, with the fracture line extended distally to the tibiofibular joint, like the type II lateral hinge fracture according to the Takeuchi classification (16) (Figure 8). Only one specimen developed a fracture that reached both the lateral plateau and distal portion of the proximal tibiofibular joint. There was no failure of the plate or screws.

Figure 8. The typical mode of failure of the axial compression test

All the causes of failures were the lateral cortical fracture with inferior extension (black arrow).

DISCUSSION

The major finding of this study is that unicortical fixation using 90% length-screws in the proximal screw holes was not inferior to the bicortical fixation in MOW HTO, while screws that are too short weaken the mechanical strength. Lateral hinge fracture reduces mechanical stability, while gap filling with bone substitute can provide additional axial stability.

Our findings partially support the hypothesis that unicortical fixation using screws of 90% length of tunnel length is not inferior to bicortical fixation, and too short (55% length of the tunnel) screw fixation weakens the mechanical stability after MOW HTO using a locking plate. Although there was a tendency that the bicortical fixation (group A) reported less medial gap change than the unicortical fixation using 90% length-screws (group B), the difference was not significant at any axial load from 0 to 600N.

Interestingly, the mean of ultimate failure load was greater in group B by 243N than group A with no statistical significance. The peak axial load in the tibiofemoral joint during level walking is reported at about three times body weight (5,49,50). As both groups showed ultimate failure load over 2000N, a corresponding load in a person with 70 kg of body weight during walking, the initial axial stability of the groups seemed to suffice for the majority of patients undergoing HTO. Our findings suggest that unicortical fixation is not inferior to the bicortical fixation if the screw length is over 90% of the tunnel length. As the far cortex of the proximal tibia is thin and the sense of drilling through the far cortex may be subtle, surgeons have to be concerned about possible neurovascular injuries to make a full length of drill hole for bicortical fixation (32). Therefore, it is not recommended to try to insert the proximal screws bicortically, risking neurovascular injury during the drilling, for the sake of clinically insignificant additional stability compared to unicortical fixation with screws of sufficient length. Unicortical fixation for the proximal screws of locking plate system is preferred in clinical practice and recommended in the manual provided by the manufacturer (15). Biomechanical studies performed bicortical fixation (15,18,25) or did not define the fixation method of proximal screws (19). Bicortical fixation has been reported superior to unicortical screw placement in an unstable proximal tibial bicondylar fracture model (20). However, the unstable bicondylar fracture model is substantially different from high tibial osteotomy, as evinced by the profoundly low ultimate failure load compared to our result (476.5 N in bicortical fixation *vs.* 258.9 N in unicortical fixation) (20). The current study supports the biomechanical evidence of unicortical fixation in the proximal screw holes of a locking plate during high tibial osteotomy.

Although unicortical fixation with 90% length-screws is comparable with bicortical fixation, placement of too short screws seemed to provide unsatisfactory axial stability. Ultimate failure load of the group C (screws with 55% length of drilled holes) was 1862.4 N, significantly lower than group E, the most stable group, whereas group B, the standard group of unicortical fixation using 90%

length-screws, was not significantly lower than group E. Considering the result of this indirect comparison and that the absolute value of failure load is less than 2000N, 55% length-screw fixation should be avoided. However, the cut-off value of acceptable screw length is neither reported in the literature nor presented in the current study.

Our findings supported the hypothesis that the lateral hinge fracture would diminish the mechanical stability. Group D, which produced the lateral hinge fracture, presented greatest medial gap change and lowest ultimate failure load. The harmful effect of the lateral hinge fracture during HTO on the osteotomy site union has been reported in clinical studies (22,23,36,51,52), but there is a controversy over the effect of the lateral hinge fracture in MOW HTO. Some researchers reported that they did not observe the lateral hinge fracture to be a risk factor of delayed union or nonunion (16,35), and others reported that additional fixation was rarely needed for the union in the undisplaced fracture or certain types of lateral hinge fracture (21,34,36). In addition, there were only a few biomechanical studies regarding the lateral hinge fracture. Miller et al. reported that the fracture of the lateral hinge resulted in a 58% reduction in axial stiffness and a 68% reduction in torsional stiffness compared to control specimens (40), similar to Stoffel et al. (19). Although the lateral hinge fracture group showed inferior axial stability in our study, the difference was not significant compared to group B, which represent the standard clinical setting, but only significant compared to group E (gap filling with bone substitute). Moreover, the ultimate failure load reached about 1700N, which seems to be not very low considering the reports of Miller et al. The different result of the two studies may be largely attributed to the locking plate mechanism of the TomoFix® in the current study, which provides angular stability (18,19). This finding suggests that the clinical situation of the lateral hinge fracture can be acceptably managed with cautious and delayed weight bearing, if the osteotomized tibia was fixated using a long, rigid locking plate, in agreement with Stoffel et al. (19). Several clinical studies found that the TomoFix® plate (DePuy Synthes, West Chester, PA, USA) yielded better clinical outcomes than short spacer non-locking plate or another type of locking plate for bone union and correction angle maintenance (36,53). Nevertheless, as lateral hinge fracture causes decreased stability after MOW HTO, caution and clinical suspicion is essential intraoperatively and in the early postoperative period. When disruption of the lateral cortex is detected, choosing a long, rigid locking plate as the fixation implant is recommended, and modification of rehabilitation protocol should be considered (21,34,36,53). In a specific clinical situation of unstable lateral hinge fracture, such as Takeuchi type II, which the fracture reaches the distal portion of the proximal tibiofibular joint, additional lateral fixation also should be in the possible list of management option (21,34,40). However, this study could not completely address whether the lateral hinge fracture should be additionally stabilized in the lateral side or not, along with a medial long rigid locking plate, especially according to the fracture type.

Our finding also supported the hypothesis that the gap filling with bone substitute would reinforce mechanical stability in MOW HTO, in accordance with the only previous study that presented mechanical effect of the bone substitute in MOW HTO (25). Group E (gap filling with bone substitute) presented the least medial gap change and highest ultimate failure load among the five study groups. Since the bone substitute is loaded, it shares the stress transmitted through the plate, explaining the findings (25). However, the effect of the bone substitute was not substantial compared to a report (25) of about 1.7 times ultimate failure load of the group without void filling (4270 N *vs.* 2500N). Bone substitute increased the ultimate failure load of 972.3N and 729.3 N compared to group A and B, respectively. This difference may mainly stem from the characteristics of the bone substitute. We used the geneX®, an injectable bone substitute that contains β -tricalcium phosphate and calcium sulphate, different from an earlier study that used β-TCP wedges (25). Surgeons should be well-informed of the detailed information of the bone substitute they would use in void filling during MOW HTO, especially if the purpose is to provide additional stability.

This study has several limitations to be considered. First, it was an in vitro cadaveric biomechanical study, so caution should be exercised when extrapolating the results of this study to the clinical situation. Second, this study was underpowered to determine the statistical significance of the mean difference between the groups. We found a significant variation of the test results between the specimens, even in the same group. This individual variation may stem from the different demographics, such as age and sex, and the bone density of the tibia.

Although we performed the CT scan to screen the osteoporotic tibiae for specimen preparation, there were larger differences in the test results among the specimens than we expected. However, we found some significant differences in several comparisons, along with some tendency with marginal p-values. We designed this study based on the several biomechanical studies that mostly used synthetic tibial models, not cadaveric specimens. These individual variations may reflect the clinical situation better than the studies of synthetic tibiae with identical mechanical properties. Third, the length of the drilled tunnel for screws can be changed according to the plate position. However, a single surgeon performed all procedures and applied the locking plate on best fitting position of the medial proximal tibia, typically 1 cm below from the plateau. There was no difference in the drilled tunnel length of each screw holes between the groups. Fourth, lateral hinge fracture of the group D in this study represents the type I according to the Takeuchi classification (21). The clinical result of each type of lateral hinge fracture was different, so the mechanical effect of each fracture type may also differ. Fifth, we harvested only tibiae for the experiment, other than the fibula and attached soft tissue. Especially, considering the mode of failure was the fracture of the lateral metaphysis or plateau, a fibula may affect the stability, supporting the lateral tibial plateau at the proximal tibiofibular joint. Sixth, the additional mechanical strength provided by a bone substitute is valid only at the time zero point, because it resolves with time. Depending upon the component of the bone substitute, the period that the bone substitute contains mechanical strength may differ. In addition, there were studies reported unfavorable union rate of synthetic bone substitute compared to autograft, allograft or no graft (24,43). Therefore, clinical relevance of using synthetic bone substitute to enhance mechanical stability may be limited considering the clinical outcome studies. Seventh, the correction gap of osteotomy site was 10mm in all specimens. Considering that the increased osteotomy angle is directly associated with loss of resistance to axial compression forces (30), greater or less correction than 10 mm gap would present a different result from our data. Finally, we tested only axial stability, and other components of mechanical stability such as torsional stability were not addressed. Further biomechanical or finite element method (FEM) studies are warranted to address these limitations.

Conclusion

Unicortical fixation using 90% length-screws in proximal screw holes of a locking plate was not inferior to the bicortical fixation regarding axial stability in MOW HTO, although proximal screws that are too short should be avoided. Lateral hinge fracture may cause unsatisfactory stability after MOW HTO, while gap filling with bone substitute can provide additional axial stability. These findings should be considered during MOW HTO to achieve satisfactory stability.

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국문 초록

목적: 잠김금속판을 이용한 내측 개방성 근위경골절골술 시 여러 요인들이 안정성에 영향을 미칠 수 있다. 본 연구에서는 금속나사의 길이, 외측 경첩 골절 유무 및 골 결손부 충전 여부가 술 후 안정성에 영향을 미치는지에 대하여 연구하였다.

대상 및 방법: 저자는 신선동결 사체에서 채취한 40개의 경골을 5개의 실험군으로 무작위배정 하여 잠김금속판을 이용한 내측개방성 근위경골절골술을 시행하였다. A 군은 양피질고정을 시행하였고, B 군과 C 군은 각각 천공 터널길이의 90% 및 50%의 길이에 해당하는 나사를 이용하여 단피질 고정을 하였다. D 군은 외측 경첩 골절을 발생시킨 후 90%길이의 나사로 단피질고정을 시행하였다. E 군은 90% 길이의 나사로 단피질 고정을 하고 절골 부위 골결손부위를 골대체재로 충전하였다. 수술한 경골 검체에는 재료 검사 장치를 이용한 축성 압박 부하 검사가 시행되었다. 100 내지 600N 에 이르는 일련의 축성 압박력에 따른 내측 절골부위 간격의 변화와 최대 파괴 부하를 측정하였다.

결과: D 군이 가장 큰 내측 절골부위 간격 변화와 가장 작은 최대 파괴 부하를 보인 반면, E 군이 가장 작은 내측 간격 변화 및 가장 큰 최대 파괴 부하를 기록하였다. 내측 절골부위 간격은 고정나사의 길이가 짧을

수록 증가하는 양상을 보였으나, A/B/C 군간의 차이는 통계적으로 유의하지는 않았다. C 군과 D 군은 E 군과 비교하였을 때 통계적으로 유의하게 큰 내측 절골부위 간격과 낮은 최대 파괴 부하를 기록하였으나, A 및 B 군과의 차이는 유의하지는 않았다.

결론: 내측 개방성 근위경골절골술 시행 시 절골부위 근위부 나사의 길이에 있어 단피질고정이 양피질고정에 비해 열등하지는 않다. 그러나 과도하게 짧은 나사의 사용은 안정성을 저해한다. 외측 경첩 골절은 안정성을 저해하는 반면, 골대체재를 이용한 골결손부위 충전은 축성 안정성을 증가시킨다. 근위경골절골술 시 적절한 안정성을 얻기 위하여 이러한 소견들을 고려해야 한다.

주요어: 골관절염, 슬관절, 경골, 절골술, 잠김금속판, 안정성, 외측 경첩 골절

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