

Peer Review File

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Reviewers' comments:

Replies to Reviewer A

Comment 1: This is an interesting study looking at a novel HTO involving the elevation of the medial tibial plateau to change the med tibial angle and move weight bearing to a more central area on the tibia and comparing the hinge points adjacent to the tibial eminence with respect to the size of the opening wedge required. Complex mathematical analysis was performed to confirm that the lateral hinge position provided the smallest gap to improve alignment and the authors considered that this was likely

to produce fewer complications. Overall, the methodology was complex and difficult to follow and would benefit from simplification in the manuscript (the complex side of the equations and measurement could be included in an appendix. My overall criticism of the procedure/methodology relates to the fact that this type of osteotomy "breaks" the joint line at the region of the hinge and so the lateral tibial plateau does not change its alignment relative to the mechanical axis. I am afraid that I don't understand the rationale for this and how precise joint line measurements can be constructed when in fact the joint has been made incongruous. The medial joint line is elevated, the lateral joint line stays the same and so there must be some weight bearing incongruity developed. Measuring the post-op joint line from the highest lateral point does not take into account that the lateral side has not changed (figure 1) and the medial joint line has now been elevated into a VARUS position, creating incongruity, and difficulty measuring the actual orientation of the joint line. I don't dispute the results of the amount of opening but struggle to understand the joint line orientation.

Reply 1: Thank you very much for your comments. Tibial condylar valgus osteotomy (TCVO) is an intra-articular proximal tibial osteotomy developed in 1990 in Japan. This is the first study discussing the selection of the hinge point during TCVO. As identified by all the reviewers, the topic is interesting. The repetitive information has been simplified for easier understanding. The Materials & Methods section has been thoroughly abbreviated. The "Detailed procedure" section (page 10 to 13, line 214 to 286) that describes schematic figure creation and surgical simulation was reduced from 6 parts to 4 parts, which not only enhanced the readability but also ensured better understanding of the mathematical description and simulated re-alignment

process. The mathematic measurement was present in the main text, which was supposed to prevent missing the important information during review. The schematic figures were modified with thicker lines, clearer color and larger size, which made it easier to distinguish. The mathematic equations were presented in the main text, which adds to preciseness and accuracy of the results. Figure legends have been rephrased to shorter ones. We shortened and rewrote part of the discussion section (page 17 to 18, line 362 to 396) but ensured the presentation of the context, main finding, argumentation and potential implications of the study. We also improved the language expression, which has been highlighted in red in the revised manuscript. All these revisions ensure the reviewers can digest the ingenious rationale and solid mathematic logic under the complexity of the topic.

As premises, during TCVO, the femoral condyle is wedged from both sides as the shape of the tibial plateau became concave, which brings adaptive adjustment on the joint surface and restores limb malalignment. It seems that in our model the static lateral tibial plateau does not change its alignment relative to the mechanical axis. However, in fact the medial tibial plateau, the medial tibiofemoral joint and femur were all elevated. More importantly, the direction of gravity was changed at the same time in this model. In other words, the medial tibial plateau, the medial tibiofemoral joint, the femur and the and direction of gravity can also be regarded as static elements, and the lateral tibial plateau is elevated during TCVO. The weight-bearing axis is therefore restored, which means the stress orientation moves from the medial to the lateral joint surface. It seems that weight bearing incongruity was developed. However, the medial and lateral tibial plateau and gravity should all be taken into consideration when assessing the weight bearing status. According to the basic concepts of deformity analysis, joint line refers to the line tangent to the joint surface. TCVO procedure actually makes the tibial plateau to become a little concave for restoring limb alignment and correct joint instability. Many studies have used this line for measuring MPTA and JLCA before and after TCVO [1, 2, 3]. Hence, measurement of joint line after TCVO is feasible.

Overall, in this study the simulated re-alignment process at the coronal plane was transformed into a simplified geometric model. The key anatomical points were allocated Cartesian coordinates and imported into MATLAB. The degree of the opening angle of the osteotomy gap was mathematically formulated with MATLAB. The results, both identified by simulation of the re-alignment process (Figure 4) and function curves (Figure 6), clearly demonstrates that the hinge point at the lateral beak of intercondylar eminence results in the smallest opening angle after TCVO.

[1] Kuwashima U, Yonekura A, Itoh M, et al. Tibial condylar valgus osteotomy - indications

and technique. *J Exp Orthop* 2020;7:30

[2] Higuchi T, Koseki H, Yonekura A, et al. Comparison of radiological features of high tibial osteotomy and tibial condylar valgus osteotomy. *BMC Musculoskelet Disord* 2019;20:409.

[3] Chiba K, Yonekura A, Miyamoto T, et al. Tibial condylar valgus osteotomy (TCVO) for osteoarthritis of the knee: 5-year clinical and radiological results. *Arch Orthop Trauma Surg* 2017;137:303-10.

Changes in the text: Page 10 to 13, line 214 to 285; Page 17 to 18, line 362 to 397; All of the figure legends; Figures.

Replies to Reviewer B

Comment 1: Geometrical analysis of the opening gap after tibial condylar valgus osteotomy for proper hinge point selection

Thank you for the opportunity to review the manuscript. The review process aims to assess the quality and ensure the article's reliability, completeness, and consistency. It is a way to improve your manuscript, and I hope you find my comments helpful.

Overall: It is a very interesting manuscript. Methodologically, I have nothing to criticize. However, the complexity of the topic requires greater clarity in the description of certain concepts. Otherwise, the reading is excessively dense. I want to congratulate the authors for the idea and the development of their study, but I must ask them to rewrite some paragraphs to make the article more attractive.

Please see specific comments below.

Title and Running title: adequate and correct.

Abbreviation list: Correct, but you should mention "correction amount of medial proximal tibial angle" in line 74.

Reply 1: Thank you very much for your comments. In our revised version, we mentioned "Correction amount of MPTA after each surgery" for describing Δ MPTA in the Abbreviation list (see Page 4, line 77). We also made improvement in English language expression and corrected minor grammatical errors, which has been highlighted in red in the revised manuscript.

Changes in the text: Page 4, line 77.

Comment 2:

Abstract:

Correct in length, writing, and clear presentation of the objective in the final paragraph of background. I have no objections.

Key Terms: OK

Introduction:

The introduction correctly defines the problem and relates the background according to the evidence provided by previous studies.

The final paragraph includes a clear and precise description of the purposes of the study.

Materials and methods:

Lines 159 to 164: inclusion and exclusion criteria. The ones you describe are correct. Out of curiosity: anything to say about the patellofemoral joint, the indemnity, or not of the central pivot or an elevated BMI?

Reply 2: Thank you very much for your nice comments. Recently, several studies have reported inherent shortcomings of inducing patellar infra and progressive degeneration in the patellofemoral joint after

OWHTO [1, 2]. The patients with patellofemoral arthritis were usually excluded from proximal tibial osteotomy. Some surgeons reported that the modified OWHTO procedure, medial open-wedge distal tuberosity tibial osteotomy (MOW-DTO), could be a primary option among the HTO procedures to avoid patellofemoral overload. During MOW-DTO the tibial tubercle remains attached to the proximal bony segment, and thus the increase in patellofemoral contact stress associated with wedge opening can be avoided [3]. Because the change in the height of tibial tuberosity with TCVO is less than that associated with OWHTO, the adverse effects on the patellofemoral joint may be minimal compared to those associated with OWHTO [4, 5]. We believe further studies can focus on the influence of TCVO on patellofemoral joint and cartilage.

For the patients undergoing OWHTO, an elevated BMI ($\text{BMI} > 30\text{kg/m}^2$ as reported by several studies) is widely considered to be associated with inferior osteoarthritis status, poor outcome and higher incidence of complications such as correction loss, implant failure, hinge fracture, persistent postoperative pain and higher reoperation rate [6, 7, 8]. According to the adult BMI for overweight and obesity standards set by the Working Group on Obesity in China, stage I obesity is defined as $28.0 < \text{BMI} < 29.9\text{ kg/m}^2$, stage II obesity is defined as $30.0 < \text{BMI} < 39.9\text{ kg/m}^2$, and stage III obesity is defined as $\geq 40.0\text{ kg/m}^2$ [9]. Most of the patients in our study were included with the BMI under 28.0 kg/m^2 , which is not in the range of obesity. It's an interesting and clinically meaningful topic regarding the post-operative outcomes and complication rates after TCVO in patients with different BMI level. Pivot-shift test is generally used to test the anterolateral joint stability, especially for knee trauma such as the rupture of anterior cruciate ligament (ACL). Pivot-shift test was not mentioned as we focus on the geometrical analysis and surgical simulation of genu varum in this study. In fact, we are proceeding with a long-term cohort study regarding to the hinge positions, magnitude of gap opening and post-operative complications such as hinge fracture, delayed union, correction loss, and plate breakage. We will include the risk factor assessment of BMI and the follow-up result of the pivot-shift test in the further studies.

[1] Tanaka T, Matsushita T, Miyaji N, Ibaraki K, Nishida K, Oka S et al. (2019) Deterioration of patellofemoral cartilage status after medial open-wedge high tibial osteotomy. *Knee Surg Sports Traumatol Arthrosc* 27:1347–1354

[2] Kim KI, Kim DK, Song SJ, Lee SH, Bae DK (2017) Medial open-wedge high Tibial osteotomy may adversely affect the Patellofemoral joint. *Arthroscopy* 33:811–816

[3] Akiyama T, Osano K, Mizu Uchi H, et al. Distal tibial tuberosity arc osteotomy in open-wedge proximal tibial osteotomy to prevent patella infra. *Arthrosc Tech* 2019;8:e655-e662.

[4] Koseki H, Yonekura A, Horiuchi H, Noguchi C, Higuchi T, Osaki M (2017) L-shaped tibial condylar valgus osteotomy for advanced medial knee osteoarthritis: a case report. *Biomed Res* 28:4878–4882

[5] Kuwashima U, Yonekura A, Itoh M, et al. Tibial condylar valgus osteotomy - indications and technique. *J Exp Orthop* 2020;7:30

[6] Wang, F., Ma, W., Chen, J. et al. Prognostic factors for medial open-wedge high tibial osteotomy with spacer implantation in patients with medial compartmental knee osteoarthritis. *J Orthop Surg Res* 17, 50 (2022). <https://doi.org/10.1186/s13018-022-02934-8>

[7] Rosso F, Rossi R, et al. Joint Line Obliquity Does Not Affect the Outcomes of Opening Wedge High Tibial Osteotomy at an Average 10-Year Follow-up. *The American Journal of Sports Medicine*. 2022;50(2):461-470.

[8] Bonasia DE, Dettoni F, Sisto G, et al. Medial Opening Wedge High Tibial Osteotomy for Medial Compartment Overload/Arthritis in the Varus Knee: Prognostic Factors. *The American Journal of Sports Medicine*. 2014;42(3):690-698. doi:10.1177/0363546513516577

[9] The Working Group on Obesity in China Guidelines for the prevention and control of overweight and obesity in Chinese adults *Acta Nutr. Sinica.*, 01 (2004), pp. 1-4

Changes in the text: Page 9, line 181.

Comment 3: Lines 194 to 197: you are reiterating information provided in lines 176 to 181. Is this necessary?

Line 201: please change “in each case” to “for each of the references (medial, central, or lateral)”. It becomes clearer.

Reply 3: Thank you so much for your careful reviewing. We realized that the reiterated information in line 214 to 217 and line 195 to 200. In our revised version, we deleted the duplicated information in page 9, line 194 to 195 (“Pre-operative MPTA (Pre-MPTA) was defined as MPTA before the surgery”) and page 10, line 199 to 200 (“Accordingly, Δ MPTA was defined as: Δ MPTA = Po-MPTA - Pre-MPTA”). Information in page 10, line 214 to 217 was remained. “In each case” in page 11, line 221 has been rephrased as “for each of the references (the hinge set at the lateral beak, the center, and the medial beak of intercondylar eminence)” for better understanding.

Changes in the text: Page 9, line 194 to 195 and page 10, line 199 to 200; Page 11, line 221.

Comment 4: Lines 203 to 213: reiterate the information in the legend of figure 3. If you write too many reiterations, it becomes difficult to digest. If you describe exhaustively here, write a shorter legend.

Reply 4: Thank you very much for your comments. The duplicated explanation was supposed to prevent missing the important information during review. The legend of figure 3 has been rephrased to a shorter one. “In this model, the medial tibia plateau was rotated..... ideal Δ MPTA was achieved. The post-operative joint line was therefore projected as follows.....” (page 29) was deleted as the information has already been mentioned in line 224 to 230 in page 11.

Changes in the text: The legend of figure 3 in page 29.

Comment 5: Overall, M&M should be abbreviated and considered supplementary material to the detailed description of the research.

Reply 5: Thank you so much for your kind and careful reviewing. The reiterations of the information in our previous version aimed to ensure the reviewers can digest the ingenious rationale and solid mathematic logic under the complexity of the topic. In the revised version, the Materials & Methods section (Page 8 to 13) has been thoroughly abbreviated. The “Detailed procedure” section that describes schematic figure creation and simulation was reduced from 6 parts to 4 parts, which not only enhanced the readability but also ensured better understanding of the mathematical description and simulated re-alignment process.

Changes in the text: Page 8 to 13, line 165 to 286.

Comment 6: Line 276: What is the meaning of “The inter- and intra-rater reliabilities were all satisfactory.”? Please enter the ICC values. Lines 275 to 283: you reiterate the information in the text and the legend of table 2. One of the other, but not both. Always better for an excellent table to present the results with the appropriate explanation as a legend. The authors can delete the entire first paragraph (lines 273 to 274). Lines 309 to 324: again, you duplicate the information (in the legend of figure 6).

Reply 6: Thank you very much for your constructive comments. The ICC values for parameters including Δ MPTA and opening angle has been added in page 14 line 303. We carefully revised the explanation of Table 2 in the Result section (page 14, line 303 to 310) to present the results appropriately and accurately. The entire first paragraph (*Radiographic features of the opening gap and Δ MPTA correction angle among the three groups*) was deleted according to the comment. The repetitive information at the legend of figure 6 (page 31) has been simplified for easier understanding. We also improved the language expression, which has been highlighted in red in the revised manuscript.

Changes in the text: Page 14 line 303; Page 14, line 303 to 310; Page 31, legend of figure 6

Comment 7:

Discussion:

The authors should rewrite the discussion, for example, in lines 333 to 354, where you rewrite information that has been satisfactorily reflected in the introduction. It is a whole paragraph that you can skip, and in general, the discussion is excessively long, and the argumentation can and should be much lighter.

Limitations: OK

Conclusion:

I recommend deleting the sentence “Long-term investigations involving large sample size of patients treated by TCVO with different hinge points selected are still needed to confirm our conclusions.”

References: they seem to me to be correct.

Reply 7: Thank you very much for your nice comments. We have realized the excessively long discussion in the previous version of our manuscript. The whole paragraph in page 17 to 18, line 362 to 383 of the previous version was deleted. We shortened and rewrote part of the discussion section but ensured the presentation of the context, main finding, argumentation and potential implications of the study (page 18, line 385 to 397). The sentence “Long-term investigations confirm our conclusions” (page 24, line 521 to 523) was deleted according to the comment. We also made improvement in English language expression and corrected minor grammatical errors, which has been highlighted in red in the revised manuscript.

Changes in the text: Page 17 to 18, line 362 to 383; Page 18, line 385 to 397; Page 24, line 521 to 523.

Comment 8:

Figure 1: on X-rays should look for higher contrast in the lines. The green line is tough to distinguish. I recommend white or yellow lines, very well defined, somewhat thicker, and you can use continuous and discontinuous lines to differentiate types of osteotomies. In the figure, the curves plotted in red do not express what you want to show, that a greater degree of the opening gap makes the medial part of the proximal fragment align more medially and the medial portion of the distal segment more laterally. Perhaps you should draw in discontinuity of the medial plateau after virtual displacement in each of the three cases or change the degrees of transparency of the images. It is not entirely clear. The figure legend is correct.

Reply 8: Thank you so much for your kind and careful reviewing. We replaced the green lines in Figure 1 with thicker white lines, which made it easier to distinguish. The dotted lines with different colors were enlarged to clearly differentiate types of TCVO. We also change the degrees of transparency of the medial plateau after virtual displacement in each of the three cases.

Changes in the text: Figure 1; The legend of Figure 1.

Comment 9:

Table 1: OK. Table 2: you reiterate the information in the text and the legend of table 2. One of the other, but not both. Always better for an excellent table to present the results with the appropriate explanation as a legend. Figure 2: OK

Reply 9: Thank you very much for your constructive comments. We carefully revised the explanation of Table 2 in the Result section (page 14, line 303 to 309) to present the results appropriately and accurately. The repetitive information has been simplified for easier understanding. We also improved the language expression, which has been highlighted in red in the revised manuscript.

Changes in the text: Page 14, line 303 to 309.

Comment 10:

Figure 3: something like figure 1 happens. I have had to enlarge the PDF quite a bit to see the lines correctly. Here, because it is a light-colored background, the color that does not show up well is yellow. You must find a solution to make the outline clearer. The figure legend is correct. Figure 4: in this case, all the figure lines are correctly identified. The legend reiterates information described exhaustively in M&M. Brevity. Figure 5: OK. Try to reiterate to a lesser extent what is described in the text of the paper. Figure 6: you reiterate the information in the text and the legend of figure 6. One of the other, but not both.

Reply 10: Thank you very much for your constructive comments. We replaced the yellow lines in Figure 3 with thicker brown lines, which made it easier to distinguish. The text with different colors were enlarged which made the outline clearer. The legends of Figure 4, 5 and 6 have been modified to a lesser extent.

Changes in the text: Figure 3; Page 29 to 31, the legends of Figure 4, 5 and 6.

Replies to Reviewer C

Comment 1: The present study compared the opening angle of the TCVO gap in three patterns of hinge point using a retrospective clinical study, geometric modeling, and mathematical analysis. The authors concluded that the opening gap was lowest in Group L (hinge points set lateral to the center of the intercondylar eminence). Certainly, the mismatch between the factory-made locking plate and bony surface after TCVO is well experienced in actual clinical situation and the significant subcutaneous prominence of the implant can cause various postoperative symptoms. Features and concepts of TCVO As premises: 1) the strategy of TCVO is not only to correct alignment, but also to achieve joint stability and congruity; 2) the angle of correction with TCVO is limited to the point that the lateral joint is reduced; and 3) the hinge point in TCVO should be set to the lateral tip of the intercondylar eminence¹⁻⁴).

The authors seemed to correct limb alignment by TCVO, and Group M (hinge points selected medial to the center of the intercondylar eminence) in this study cannot be regarded as equivalent to the original TCVO. Moreover, in TCVO, the shape of the tibial plateau is changed to become concave, so the convex-type (also called “pagoda-type”) tibial plateau with a joint line convergence angle $>5^\circ$ on standing X-ray meets the indication criteria. Although the authors mentioned general inclusion and exclusion criteria for osteotomy (page 8, lines 159– 164), strict indication criteria for TCVO as distinct from other osteotomies should be specified, such as thresholds for limb alignment (HKA or FTA), instability, joint line convergence angles, and the geometry of anatomical morphologies.

Reply 1: Thank you so much for your kind and careful reviewing. These premises have been demonstrated in the manuscript. With the progress of knee OA, the aggravated osseocartilaginous wearing will cause intra-articular deformity characterized by inclination of the medial tibial plateau and narrowed medial joint gap (decreased medial tibial plateau depression [MTPD] and increased joint line convergence angle [JLCA]). The outcome of OWHTO procedure is not always satisfactory in these cases (page 6, line 117 to 119). During TCVO, the femoral condyle was wedged from both sides as the shape of the tibial plateau became more concave, which brings adaptive adjustment on the joint surface and restores the intra-articular stability. Alignment correction and achievement of joint stability and congruity are both the strategy of TCVO. In the revised manuscript we mentioned that TCVO has limited capacity in alignment correction (page 19, line 397 to 402). In early years when L-shaped osteotomies were performed in our institute, there are few literatures published in English on Pubmed that clearly defined the lateral tip of the intercondylar eminence as the hinge point of TCVO. We gradually notice that TCVO requires more magnitude of gap opening for angle correction when compared with OWHTO, and the opening angle is the smallest with the hinge point set lateral to the center of the intercondylar eminence during TCVO. Larger magnitude of gap opening during corrective osteotomy has been widely reported to be associated with increased risk of lateral hinge fracture and fixation failure. In actual clinical situation the mismatch between the plate-bone surface and the patients' complaints caused by the significant subcutaneous prominence of the implant are well experienced in recent years. Some

studies published in recent years have mentioned the hinge point as the lateral tip of the intercondylar eminence, while there is no study illustrating the exact reason for choosing this point. We added “Some studies published in recent years have mentioned the hinge point for choosing this point” in Page 7, line 143 to 146.

Several previous studies recommended the “pagoda-type” tibial plateau, lateral joint dilation (JLCA over 4°) and depression of the medial tibial plateau (MTPD less than - 4°) as the indications for TCVO. In fact, our study intended to include the patients of medial unicompartmental knee osteoarthritis with intra-articular deformity treated only by TCVO (page 8, line 170 to 172). We clearly understand TCVO procedure but didn't mention the definite thresholds for intra-articular deformity, which might lead to ambiguous of general inclusion and exclusion criteria for osteotomy. In the revised manuscript, we specified strict indication criteria for TCVO as distinct from other osteotomies (page 8, line 172 to 176). Changes in the text: Page 8, line 172 to 176; Page 7, line 143 to 146.

Comment 2: Complication rates after TCVO. The authors emphasized and brought up complications after TCVO, such as hinge fracture, delayed union, correction loss, and plate breakage in the Introduction and Discussion sections. However, the rates of these problems were not examined in this study. If the authors consider that the gap opening angle contributes to these complications, please provide the rates of these complications in each of the three groups and discuss appropriate cut-offs to prevent postoperative complications.

Reply 2: Thank you very much for your comments. In fact, we are proceeding with a long-term cohort study regarding to the hinge positions, magnitude of gap opening and post-operative complications such as hinge fracture, delayed union, correction loss, and plate breakage. Larger magnitude of gap opening during OWHTO has been widely reported to be associated with increased risk of lateral hinge fracture and fixation failure. Undoubtedly, TCVO shares the same trend as it is considered as a special osteotomy type of OWHTO. Moreover, in actual clinical situation the mismatch between the plate-bone surface and the patients' complaints caused by the significant subcutaneous prominence of the implant are well experienced after TCVO. Thus, the aim of this study is to find the proper hinge point that leads to the smallest gap opening angle during TCVO. Although investing the complication rates in each of the three groups and appropriate cut-offs to prevent postoperative complications is from interest as there is few evidence on this special topic. We are afraid adding these contents to the manuscript will make the manuscript too long too complicated and hard to follow. The whole manuscript has been thoroughly simplified. We believe that there is still of great benefit to describe our new findings if the advanced technique or surgical procedure could be clarified from a certain methodology, irrespective of the existence of clinical follow-up. Meanwhile, we are also proceeding with another long-term cohort study to present the clinical evidence with different hinge positions selected.

Comment 3:

Minor points

Page 7, lines 140–142: Citation is absent.

Page 8, lines 164–168: Were the hinge points selected intentionally? If so, please show the indication criteria for the three groups (medial, center, and lateral hinge points).

Reply 3: Thank you so much for your kind and careful reviewing. Citation has been added in page 7, line 151. In our study, the hinge positions were randomly selected. In fact, in early years when L-shaped osteotomies were performed in our institute, there are few literatures published in English on PubMed that clearly defined the lateral tip of the intercondylar eminence as the hinge point of TCVO. We gradually notice that TCVO requires more magnitude of gap opening for angle correction when compared with OWHTO, and the opening angle is the smallest with the hinge point set lateral to the center of the intercondylar eminence during TCVO. In actual clinical situation the mismatch between the plate-bone surface and the patients' complaints caused by the significant subcutaneous prominence of the implant are well experienced in recent years. Some studies published in recent years have mentioned the hinge point as the lateral tip of the intercondylar eminence, while there is no study illustrating the exact reason for choosing this point. Thus, we found it necessary to conduct the study on this topic.

Changes in the text: Page 7, line 151

Comment 4: Page 9, line 197: The explanations of MPTA were duplicated.

Page 10, line 202: Please provide the name of the company and its location.

Reply 4: Thank you very much for your nice comments. We realized that the reiterated information in line 214 to 217 and line 195 to 200. In our revised version, we deleted the duplicated information in page 9, line 194 to 195 (“Pre-operative MPTA (Pre-MPTA) was defined as MPTA before the surgery”) and page 10, line 199 to 200 (“Accordingly, Δ MPTA was defined as: Δ MPTA = Po-MPTA - Pre-MPTA”). Information in page 10, line 214 to 217 was remained. Page 11 line 223: The name of the company and its location was provided (Adobe Inc., Mountain View, CA, USA).

Changes in the text: Page 9, line 194 to 195 and page 10, line 199 to 200; Page 11 line 223.

Comment 5: Page 18, lines 375–376: Previous studies have mentioned hinge position as the lateral tip of the intercondylar eminence¹⁻⁴).

Page 22, lines 476–477: This study provided only the relationship between the hinge point and opening gap angle, not “a deeper understanding of safe and successful TCVO operation”. This seems to be an overstatement.

Reply 5: Thank you for your very nice suggestions. In fact, in early years when L-shaped osteotomies

were performed in our institute, there are few literatures published in English that clearly defined the lateral tip of the intercondylar eminence as the hinge point of TCVO. Some studies published in recent years have mentioned the hinge point as the lateral tip of the intercondylar eminence, while there is no study illustrating the exact reason for choosing this point. Thus, we found it necessary to conduct the study on this topic. The conclusion section has been modified (Page 24, line 520 to 523).

Changes in the text: Page 7, line 143 to 146; Page 24, line 520 to 523.

Comment 6: Figure 1

The letters in the figure are difficult to read.

The figure legend is too long.

No description has been given for Figure 1d.

Reply 6: Thank you so much for your kind and careful reviewing. We replaced the green lines in Figure 1 with thicker white lines, which made it easier to distinguish. The dotted lines with different colors were enlarged to clearly differentiate 3 types of TCVO. Moreover, figure legend has been revised for better understanding.

Changes in the text: Figure 1; The legend of Figure 1.

Comment 7: Figure 2

The need for photographs of the patient's appearance and X-rays of the lateral view are doubtful in this study.

The figure legend is too long.

The distance between feet differs between pre- and postoperative standing radiographs.

Reply 7: Thank you so much for your careful reviewing. The presentation of a typical TCVO case aims to provide a better understanding of TCVO procedure and the radiographic measurement for the readers, as requested by other reviewers. The figure legend has been reiterated to a lesser extent. We revised figure 2 and ensured the equal feet distance between pre- and postoperative standing radiographs.

Changes in the text: Figure 2; The legend of Figure 2.

Comment 8: Figure 3

The postoperative joint line crosses the lateral plateau. Is this correct? Moreover, the authors mentioned two different definitions about "point M". Which is correct, "the intersection point of pre- and post-operative joint lines" (page 30, lines 627–628) or "medial to the points at which the joint line was tangent to the lateral tibia plateau" (page 27, line 598)?

Reply 8: Thank you so much for your careful reviewing. In Figure 3 we intended to showed that the post-operative joint line was projected tangent to lateral tibia plateau, with the angle formed between

the pre- and post-operative joint lines equal to Δ MPTA. The manually painted figure may be different from the X-ray which makes it seem that the postoperative joint line crosses the lateral plateau. In order to make it easier for understanding, we added “ Δ MPTA” between the two joint lines. The two different definitions about “point M” are both correct. Point M was defined as the intersection point of pre- and post-operative joint lines. As the osteotomy gap increasing gradually until the desired Δ MPTA is achieved, point M moves along the pre-operative joint line toward the medial side. Thus, point M was located medially to the points at which the pre-operative joint line was tangent to the lateral tibia plateau.

Changes in the text: Figure 3

Replies to Reviewer D

Comment 1: The authors present an analysis of the position of the hinge point with the smallest opening angle in tibial condylar valgus osteotomy. The work is from interest as there is small evidence on this special topic. The paper is well written with excellent style.

However in general needs to be shortened, if possible in Materials and Methods and Discussion.

Abstract:

Appropriate

Introduction: Well written and interesting. In general it should be mentioned that open-wedge valgus HTO nowadays is the standard treatment (if MPTA is the cause for Varus) and TCVO is an option in special cases (Blounts disease, posttraumatic deformity ...): Perhaps give an example in Line 120.

Reply 1: Thank you very much for your comments. We mentioned that OWHTO is the standard treatment procedure for genu varum (Page 6, line 116). We also mentioned that TCVO is an option in special cases (Blount disease, post-traumatic deformity ...) (Page 6, line 123 to 127).

Changes in the text: Page 6, line 116; Page 6, line 123 to 127.

Comment 2:

Materials and Methods:

Well written, all informations are included but tiring to read, try to shorten.

Line 154: Name of the review board? Internal approval-number?

Line 162: near normal lateral ft compartment (defined as waht? KL < grade 2? MRI?)

Line 163: knee osteoarthritis (KL grade?)

Discussion: Well written, appropriate - bit too long try to shorten.

Limitations: Appropriate

Conclusion: Appropriate

References: Appropriate

Figures and Tables: Appropriate

Reply 2: Thank you so much for your kind and careful reviewing. The excessive length of Materials and Methods was supposed to prevent missing the important information during review. The reviewers can digest the solid mathematic logic and ingenious rationale under the complexity of the topic. In the revised version, the excessive length of the Materials and Methods (Page 8 to 13) has been thoroughly shortened. The “Detailed procedure” section that describes schematic figure creation and simulation was reduced from 6 parts to 4 parts, which not only enhanced the readability but also ensured better understanding of the mathematical description and simulated re-alignment process. Name of the review board and internal approval-number have been provided in page 8, line 166. “Near-normal lateral femorotibial compartment” (page 9, line 178) and “lateral unicompartmental knee osteoarthritis” (page

9, line 182) were clearly defined for better understanding of the inclusion and exclusion criteria.
Changes in the text: Materials and Methods (Page 8 to 13); Page 8, line 166; Page 9, line 178; Page 9, line 182.