

1 **Abstract**

2 Aims. This multicenter study attempts to make recommendations as to when cementless Oxford
3 Unicompartmental Knee Arthroplasty (OUKA) tibial components can safely be used in an
4 Asian population.

5 Methods. 212 knees in 174 patients in six hospitals who underwent cementless OUKA were
6 studied. On pre-operative radiographs the medial eminence line (MEL), which is a line parallel
7 to the tibial axis passing through the tip of medial intercondylar eminence, was drawn. Knees
8 were classified as having an overhanging condyle if the MEL passed medial to the medial tibial
9 cortex and very small if a size A /AA tibial component was used.

10 Results. Overall the fracture rate was 8%. With overhanging condyles the odds ratio of fracture
11 was 13 ($p<0.0001$) and with very small components it was 7 ($p=0.0004$). With both
12 overhanging condyles and very small components the odds ratio was 21 ($p=0.0001$). 69% of
13 knees had neither overhanging nor very small components and in these the fracture rate was 1%.

14 Conclusion. It is recommended that in Asia cemented tibial fixation should be used for cases
15 that have overhanging condyles or need very small components. In the remaining 70% of cases
16 cementless fixation can be used.

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Introduction

In cohort studies the Oxford unicompartmental knee arthroplasty (OUKA) has achieved excellent clinical outcomes and good long-term survival^{1 2}. However, reports from National Joint Registries have shown that the revision rate of the OUKA is higher than that of total knee arthroplasty (TKA)³. Common reasons for revision are aseptic loosening and pain. Misinterpretation of radiolucent lines that commonly occur under the tibial component of the cemented OUKA may have contributed to these revisions⁴.

The cementless OUKA was introduced to address the high revision rate and has been reported as having equivalent or better clinical outcomes than the cemented OUKA with markedly reduced radiolucent lines⁵. Recent reports from the New Zealand Joint Registry have also shown that the revision rate of the cementless OUKA is about half that of the cemented⁶. However there is a concern about an increased risk of tibial plateau fracture^{4 7}. Although tibial fractures are reportedly rare after UKA, they are a serious complication that typically present in the first few weeks after the operation. Several factors have been identified that may increase the risk of fracture. Probably the most important is a keel slot that is too small, so hard impaction of the component is required⁸: It is essential the trial tibial component can be inserted with finger pressure before the definitive component is impacted. If it can't then the slot should be enlarged. Other factors include deep or medial sagittal cuts, damage to the posterior cortex⁷, and multiple pin usage for fixation the tibial cutting block⁹. These factors all relate to surgical technique suggesting that, at least for a western population, the risk of fracture should be very low (<1%) with careful technique.^{4 10 11}

After the introduction of cementless OUKA in Japan in September 2015, tibial fractures occurred relatively frequently, despite the surgeons being experienced and using recommended techniques¹². This suggests that, in an Asian population, patient factors are important in the aetiology of tibial fractures. Fractures in Japan were observed to be common with the very small tibial sizes (A and AA), which are rarely used in Caucasians. Bone morphology is also different in Asians and Caucasians. Proximal tibia vara is common in Japanese population¹³. This is associated with an overhanging medial tibial condyle, which reduces the bone volume under the tibial tray and may increase the risk of fracture. We retrospectively evaluated this by drawing a

line on pre-operative antero-posterior radiographs, parallel to the tibial axis passing through the medial intercondylar eminence¹⁴. This medial eminence line (MEL) lies where the vertical tibial cut is made, and we found that if the line passed medial to the medial cortex of tibial shaft there was an increased risk of tibial plateau fracture after cementless OUKA. However, this study involved a small number of patients in a single center and as a result is of limited value. Therefore the aim of this large multicenter study was to assess the effect of tibial size and morphology on fracture risk and to attempt to make recommendations as to when cementless tibial components can safely be used in an Asian population.

Patients and methods

This retrospective study was approved by institutional review boards in all centers. Six hospitals with experienced surgeons participated in this study. From September 2015 to December 2017, 212 knees in 174 patients who underwent OUKA with cementless tibial components were included in this study. There were 57 males and 117 females and the mean age was 72.4 years (47 to 90). The mean BMI was 25.4 kg/m² (18.0 to 38.6). 189 knees were the anteromedial osteoarthritis of the knee (AMOA)¹⁵ with full-thickness cartilage defect on medial compartment, functionally intact anterior cruciate ligament and intact lateral compartment and the remain 23 knees were the spontaneous osteonecrosis of the knee (SONK). The standard operative procedure was performed using Microplasty® instruments¹⁶ in every patient in all institutions. The tibia was cut using the company provided a tibial cutting guide following the built-in alignment of 7° in posterior slope and perpendicular to the tibial axis. The sagittal cut was made at just medial to the apex of the medial tibial spine aiming to the anterior-superior iliac spine taking great care to avoid the deep cut. The keel slot was made with the specialized saw for the cementless tibial component that makes a slot with a slightly narrower width than the keel width to achieve the interference for a secured initial fixation. The tibial component was inserted with mild taps using a light hummer, avoiding an intraoperative fracture. No fracture was recognized intraoperatively and on the radiographs just after the operation.

Preoperative antero-posterior radiographs were collected and analyzed. The tibial morphology was assessed using the method we previously described¹⁴. The tibial axis was identified by

joining the midpoints of the tibia 6cm and 12cm below the joint line. The medial eminence line (MEL) was drawn passing through the apex of the medial intercondylar eminence and parallel to the tibial axis. The MEL was considered to be the lateral border of the medial tibial condyle. If the MEL was outside the tibial diaphysis, the tibia was classified as extramedullary type and the medial tibial condyle was considered to be overhanging. Otherwise, the tibia was classified as intramedullary type and medial condyle was considered to be not overhanging (Fig. 1). As well as subdividing knees according to their morphology, we subdivided them into those that had very small tibial components (A and AA) and those that did not. We also determined which knees had and had not sustained a peri-prosthetic tibial plateau fracture.

We explored the relationship between morphology, size and fracture and determined the odds ratio of fracture in the various subgroup. All statistical analyses were preformed using EZR (<http://www.jichi.ac.jp/saitama-sct/SaitamaHP.files/statmed.html>)¹⁷.

Results

There were 17 fractures in the 212 knees studied, making the overall fracture rate 8%.

As shown in Table 1, male patients had a significant reduced risk of fracture. Regarding other parameters (age, BMI, pre- and post FTA, pre- and post HKA), there were no significant difference between fractures and non-fractured subjects.

19% (41/212) of the knees were considered to have medial tibial condyle overhang and 81% (171/212) did not (Table 2). The fracture rate with medial condyle overhang was 29% (12/41) and without with medial condyle overhang was 2.9% (5/171). The odds ratio of fracture was 13.46 (95% Confidence interval (CI) 4.05 to 52.53, $p < 0.0001$).

17.0% (36/212) of the knees had very small (A or AA) tibial components implanted and 83.0% (176/212) had standard sized components (B or larger) implanted (Table 3). The fracture rate with the standard components was 4.5% (8/176) and with the very small components was 25% (9/36). The odds ratio of fracture was 6.90 (2.16 to 22.57, $p = 0.0004$).

31% (65/212) of the knees had medial condyle overhang or required very small (A or AA) components. The remaining 69% (147/212) did not have condyle overhang and had standard (B or larger) components (Table 4). The fracture rate in the group that had medial condyle overhang or required very small components was 23% (15/65) and in the remaining knees the fracture rate was 1.4% (2/147). The odds ratio of fracture was 21.41 (CI 4.73 to 198.93, $p = 0.0001$).

The knees that required very small (AA or A) tibial components tended to have medial condyle overhang with an odds ratio of 2.52 (95% CI 1.03 to 5.97, $p = 0.0034$) (Table 5). Similarly, female patients had a higher proportion of knees with medial condyle overhang than males (odds ratio 2.52, 95% CI 1.03 to 5.97 $p = 0.0034$) (Table 6). There was no significant difference in BMI between patients who had or did not have medial condyle overhang ($25.0 \pm 3.3 \text{ kg/m}^2$ and $25.3 \pm 4.4 \text{ kg/m}^2$, respectively, $p = 0.341$).

Discussion

This multicenter study has demonstrated that in Japan experienced surgeons routinely using the Oxford Cementless UKA have a high tibial plateau fracture rate (8%). This contrasts with Europe where registry data¹⁸ shows the fracture rate is low (<1%), suggesting that patient factors are important. Aside from the gender difference, we have identified two factors relating to tibial shape and size that probably explain most of the difference: Patients that have overhanging medial tibial condyles and those of very small size have an increased rate of fracture. If these patients have cemented rather than cementless tibial components, the overall risk of tibial plateau fracture should drop to an acceptable level.

Overhanging medial tibial condyles, defined as an extramedullary MEL, were associated with a 13 times increased risk of fracture. This finding is similar to that of our previous single center study¹⁴, however in the multicenter study the numbers are large enough to make suggestions as to how patients should be managed. On the basis of our findings it would seem sensible not to use cementless tibial components if there is tibial condyle overhang. The MEL is approximately the position of the sagittal tibial cut. If the MEL is extramedullary the whole medial tibial condyle and, after the operation, the tibial component overhang the tibial diaphysis. Therefore it

is not surprising that there is an increased risk of fracture as there is a decreased bone volume under the tibial component and shortened distances from the cortex to the keel slot and to the sagittal tibial cut. Patients with an overhanging medial tibial condyle are likely to have tibia vara, which is common in Asian populations^{19 20 21 22 23}. However we found, in our previous study, that the position of the MEL was a better predictor of fracture than tibia vara¹⁴. Furthermore methods of assessing tibia vara^{19 24 25 22} usually require full-length radiographs of the tibia, whereas the MEL assessment is simpler and can be done on standard knee radiographs.

The risk of fracture with the small cementless tibial components (A and AA) was 7 times higher than the larger sizes, so it would seem sensible to avoid using these components. It is not certain why these components are associated with an increased risk of fracture but it is probably because they are used in very small tibias and the tibial cortex is very close to keel and may be damaged and weakened during preparation or insertion of the keel. In Europe, although these very small size components are rarely used, they do not seem to have caused such a problem with fractures. So perhaps the shape of the tibia is also important, supporting evidence for this is that patients treated with the very small tibias were found to be more likely to have tibial condyle overhang than larger patients. Whatever the reason it would seem sensible to consider having smaller keels on the very small components as currently all components, whatever their size, have the same depth keel.

If cementless components are not used in cases with tibial overhang then the fracture rate in the remaining cases would be about 3%. Similarly if they were not used with the very small sized components the rate in the remaining cases would be 5%. In both situations the residual fracture rate seems high. However if cementless components were not used in cases needing either small sizes or with condylar overhang then the fracture rate would be about 1% in the remaining cases which is probably acceptable. This approach would exclude about 30% of UKR so it would seem to be the best compromise solution.

Although there is no good data about the tibial fracture rate following the cemented Oxford UKA in Japan it is much lower than following cementless Oxford UKA and is probably 1% or

less. Therefore if cemented tibial components were used in patients with overhanging condyles or small components, and cementless components were used in the rest the overall fracture rate would be about 1%. There are a number of reasons why cemented tibial components are less likely to cause fracture than cementless⁷. The cementless keel has an interference fit so tends to cause a splitting force in the tibia, which does not occur with cement^{26 27 28 29}. To achieve this interference the component has to be impacted which can cause cracks that subsequently propagate³⁰. Fractures tend to present one to three weeks after surgery and occasionally a “take off sign”, which is a slight separation between bone and medial surfaces of the tibial component can be seen, before they complete (Fig. 2). This separation might be prevented by the cement holding the bone together.

We defined the MEL on the short knee radiographs referencing to the line connecting the midpoints at 6 cm and 12 cm below the joint line. The line might be slightly different from the actual tibial mechanical axis. However, the mechanical axis is measured on a whole leg long radiographs that require additional cost and irradiation. We found enough predictive ability in the tibial fracture after the usage of the cementless tibia, indicating that the MEL that is calculated by our method using standard short knee radiographs is preferable.

The surgical aim with the Oxford UKA has always been to implant the tibial component perpendicular to the tibial axis in the coronal plane. To achieve this an extra-medullary tibial saw guide is used and is positioned centrally over the ankle. With this approach excellent long term result have been achieved². Furthermore, in European patients, there has been no compromise in results using this technique in patients with tibia vara³¹. It is however possible that in Japanese patients with tibia vara and an overhanging condyle, implanting the component in more varus might decrease the risk of fracture, and there is some finite element analysis data that would support this³². As can be seen in Figure 3 in a patient with marked tibia vara and medial condyle overhang if, instead of implanting the component perpendicular to the mechanical axis of the tibia it was implanted in more varus, perhaps perpendicular to the mechanical axis of the femur with the knee in extension, the risk of fracture might decrease. This is because the tibial component would be more lateral, so a larger component could be used, there would be more bone supporting the component, and the keel would be further from

the cortex. In addition the load, which is perpendicular to the tibial surface and passing through the center of the femur would be directed more laterally.

Concerning the fixed-bearing UKA, where the original joint surface is considered to be reconstructed, a slight varus cut has been accepted³³. Besides, several mechanical studies have shown that a mild varus coronal alignment is advantageous to decrease mechanical stress on the tibia and the risk of stress fracture^{34 32}. On the other hand, few reports have been available regarding the tibia alignment in the coronal plane. Rivière et al.³⁵ conducted the computer simulation study and revealed that a varus aligned tibial tray in Oxford UKA showed better adaptation than mechanical aligned (perpendicular to the tibial axis) tray. Dai et al.³⁶ reported that a slight varus implantation of the Oxford tibial tray reduced the peak stress on the medial cortex in a 3-D finite element analysis study. In addition, these experimental studies, the acceptable range of tibial component alignment has been considered within $< 5^{\circ}$ varus to $< 5^{\circ}$ valgus³⁷. Clarius et al.³⁸ retrospectively reported that the postoperative tibial component alignment did not affect the postoperative outcome. Although changing the cutting technique from mechanical to slight varus alignment is festinating, a clinical study should be undertaken to ensure there is no compromise in outcome with this modified technique.

This study has some limitations. Firstly, as this was a multicenter study details of the surgical technique may have varied between surgeons and was not studied. However, the surgeons involved were very experienced and had low fracture rates with cemented tibial components. Secondly, the radiographic study was two dimensional and rotation of the leg might change the relationship between the MEL and the tibial cortex. Further study would be needed to evaluate the relationship. However, we believe that the standard radiograph is sufficient because of the satisfactory discriminative ability of the MEL. Finally, we did not measure the bone mineral density (BMD). Yokoyama et al.³⁹ reported that low BMD in the affected femur might contribute to a stress fracture of the tibia after UKA as low BMD is directly related to an increased risk of fracture. Further investigation will be needed to clarify the contribution of the BMD on the fracture occurrence.

Conclusion

The multicenter study suggests that, in an Asian population, to capitalize on the advantages of cementless fixation without increasing the risk of tibial fracture, in addition to careful surgery: Hybrid fixation, with cemented tibia and cementless femur, should be used with medial condyle overhang defined as an extramedullary MEL and with small sizes tibial components (A and AA), and fully cementless fixation can be used in the remainder. In the future with improvements in implants and surgical technique it may be possible to use fully cementless fixation in all patients.

References

1. **Liddle AD, Judge A, Pandit H, Murray DW.** Adverse outcomes after total and unicompartmental knee replacement in 101,330 matched patients: a study of data from the National Joint Registry for England and Wales. *Lancet* [Internet] 2014 [cited 8 Nov 2018];384(9952):1437–1445.
2. **Price AJ, Svard U.** A second decade lifetable survival analysis of the oxford unicompartmental knee arthroplasty. *Clin Orthop Relat Res* 2011;469(1):174–179.
3. **Niinimäki T, Eskelinen A, Mäkelä K, Ohtonen P, Puhto AP, Remes V.** Unicompartmental knee arthroplasty survivorship is lower than TKA survivorship: A 27-year finnish registry study. *Clin Orthop Relat Res* 2014;472(5):1496–1501.
4. **Liddle AD, Pandit H, O'Brien S, Doran E, Penny ID, Hooper GJ, et al.** Cementless fixation in Oxford unicompartmental knee replacement: A multicentre study of 1000 knees. *Bone Joint J* [Internet] 2013;95-B(2):181–187.
5. **Hooper N, Snell D, Hooper G, Maxwell R, Frampton C.** The five-year radiological results of the uncemented Oxford medial compartment knee arthroplasty. *Bone Jt J* 2015;97-B(10):1358–1363.
6. **Listed N authors.** New Zealand Joint Registry nineteen year report. https://nzoa.org.nz/system/files/DH8152_NZJR_2018_Report_v6_4Decv18.pdf ((date last accessed%0D16 November 2019) ,.
7. **Jäger S, Clarius M, Röhner E, Tohtz S, Haas D, Seeger JB.** Extended sagittal saw cut significantly reduces fracture load in cementless unicompartmental knee arthroplasty compared to cemented tibia plateaus: an experimental cadaver study. *Knee Surgery, Sport Traumatol Arthrosc* 2012;20(6):1087–1091.
8. **Loon P Van, Munnynck B De, Bellemans J.** Periprosthetic fracture of the tibial plateau after unicompartmental knee arthroplasty. *Acta Orthop Belg* 2006;72(3):369–374.

- 269 9. **Brumby SA, Carrington R, Zayontz S, Reish T, Scott RD.** Tibial plateau stress
270 fracture: a complication of unicompartmental knee arthroplasty using 4 guide pinholes. *J*
271 *Arthroplasty* [Internet] 2003 [cited 21 Jul 2019];18(6):809–12.
- 272 10. **Svärd UCG, Price AJ.** Oxford medial unicompartmental knee arthroplasty A
273 SURVIVAL ANALYSIS OF AN INDEPENDENT SERIES. *J Bone Jt Surg [Br]*
274 2001;83(2):191–4.
- 275 11. **Campi S, Pandit H, Hooper G, Snell D, Jenkins C, Dodd CAF, et al.** Ten-year
276 survival and seven-year functional results of cementless Oxford unicompartmental knee
277 replacement: A prospective consecutive series of our first 1000 cases. *Knee Elsevier*
278 B.V., 2018;25(6):1231–1237.
- 279 12. **Okimura K, Hiranaka T, Fijishiro T, Hida Y, Shibata Y, Tsubosaka M, Nakanishi**
280 **Y UH.** Tibial Fractures after cementless Oxford unicompartmental knee arthroplasty - a
281 report of five cases [in Japanese]. *Japanese J Replace Arthroplast* 2017;47:207–208.
- 282 13. **Mori S, Akagi M, Asada S, Matsushita T, Hashimoto K.** Tibia vara affects the aspect
283 ratio of tibial resected surface in female Japanese patients undergoing TKA. *Clin Orthop*
284 *Relat Res* [Internet] Association of Bone and Joint Surgeons, 2013 [cited 22 Mar
285 2019];471(5):1465–71.
- 286 14. **Yoshikawa R, Hiranaka T, Okamoto K, Fujishiro T, Hida Y ST.** The medial
287 eminence line can predict tibial fracture risk after unicompartmental knee arthroplasty.
288 *Clin Orthop Surg* .
- 289 15. **White SH, Ludkowski PF, Goodfellow JW.** Anteromedial osteoarthritis of the knee. *J*
290 *Bone Jt Surg* 1991;73-B(4):582–586.
- 291 16. **Biomet Z.** Oxford® Partial Knee Microplasty® Instrumentation Surgical Technique.
292 [https://www.zimmerbiomet.com/content/dam/zimmer-biomet/medical-professionals/000-](https://www.zimmerbiomet.com/content/dam/zimmer-biomet/medical-professionals/000-surgical-techniques/knee/oxford-partial-knee-microplasty-instrumentation-surgical-technique.pdf)
293 [surgical-techniques/knee/oxford-partial-knee-microplasty-instrumentation-surgical-tech-](https://www.zimmerbiomet.com/content/dam/zimmer-biomet/medical-professionals/000-surgical-techniques/knee/oxford-partial-knee-microplasty-instrumentation-surgical-technique.pdf)
294 [nique.pdf](https://www.zimmerbiomet.com/content/dam/zimmer-biomet/medical-professionals/000-surgical-techniques/knee/oxford-partial-knee-microplasty-instrumentation-surgical-technique.pdf) ,.
- 295 17. **Kanda Y.** Investigation of the freely available easy-to-use software ‘EZR’ for medical
296 statistics. *Bone Marrow Transplant* [Internet] Nature Publishing Group, 2013 [cited 17
297 Feb 2019];48(3):452–458.
- 298 18. **Mohammad HR, Matharu GS, Judge A, Murray DW.** Comparison of the 10-year
299 outcomes of cemented and cementless unicompartmental knee replacements: data from
300 the National Joint Registry for England, Wales, Northern Ireland and the Isle of Man.
301 *Acta Orthop* 2019;91(1):76–81.
- 302 19. **Yau WP, Chiu KY, Tang WM, Ng TP.** Coronal Bowing of the Femur and Tibia in
303 Chinese: Its Incidence and Effects on Total Knee Arthroplasty Planning. *J Orthop Surg*
304 2016;15(1):32–36.

- 305 20. **Lasam MPG, Lee KJ, Chang CB, Kang YG, Kim TK.** Femoral lateral bowing and
306 varus condylar orientation are prevalent and affect axial alignment of TKA in Koreans
307 knee. *Clin Orthop Relat Res* 2013.
- 308 21. **Ko PS, Tio MK, Ban CM, Mak YK, Ip FK, Lam JJ.** Radiologic analysis of the tibial
309 intramedullary canal in Chinese varus knees: Implications in total knee arthroplasty. *J*
310 *Arthroplasty* [Internet] Churchill Livingstone, 2001 [cited 22 Mar 2019];16(2):212–215.
- 311 22. **Nagamine R, Miura H, Bravo C V., Urabe K, Matsuda S, Miyanishi K, et al.**
312 Anatomic variations should be considered in total knee arthroplasty. *J Orthop Sci*
313 2000;5(3):232–237.
- 314 23. **Yoo JH, Kang YG, Chang CB, Seong SC, Kim TK.** The relationship of the
315 medially-offset stem of the tibial component to the medial tibial cortex in total knee
316 replacements in Korean patients. *J Bone Joint Surg Br* [Internet] The British Editorial
317 Society of Bone and Joint Surgery, 2008 [cited 22 Mar 2019];90-B(1):31–36.
- 318 24. **Thippana RK, Kumar MN.** Lateralization of tibial plateau reference point improves
319 accuracy of tibial resection in total knee arthroplasty in patients with proximal tibia vara.
320 *CiOS Clin Orthop Surg* 2017;9(4):458–464.
- 321 25. **Yoo JH, Kang YG, Chang CB, Seong SC, Kim TK, Kang YG, et al.** The relationship
322 of the medially-offset stem of the tibial component to the medial tibial cortex in total
323 knee replacements in Korean patients. *J Bone Joint Surg Br* [Internet] 2007 [cited 22
324 Mar 2019];90(1).
- 325 26. **Damm NB, Morlock MM, Bishop NE.** Friction coefficient and effective interference at
326 the implant-bone interface. *J Biomech* 2015;48(12):3517–3521.
- 327 27. **Nowak M, Kusz D, Wojciechowski P, Wilk R.** Risk factors for intraoperative
328 periprosthetic femoral fractures during the total hip arthroplasty. *Pol Orthop Traumatol*
329 2012;77:59–64.
- 330 28. **Scott CE, Eaton MJ, Nutton RW, Wade FA, Evans SL, Pankaj P.** Metal-backed
331 versus all-polyethylene unicompartmental knee arthroplasty: Proximal tibial strain in an
332 experimentally validated finite element model. *Bone Jt Res* 2017;
- 333 29. **Campi S, Mellon SJ, Ridley D, Foulke B, Dodd CAF, Pandit HG, et al.** Optimal
334 interference of the tibial component of the cementless Oxford Unicompartmental Knee
335 Replacement. *Bone Joint Res* 2018;7(3):226–231.
- 336 30. **Pandit H, Murray DW, Dodd CAF, Deo S, Waite J, Goodfellow J, et al.** Medial
337 tibial plateau fracture and the Oxford unicompartmental knee. *Orthopedics* [Internet]
338 2007;30(5 Suppl):28–31.

31. **Kennedy JA, Molloy J, Jenkins C, Mellon SJ, Dodd CAF MD.** Functional Outcome and Revision Rate Are Independent of Limb Alignment Following Oxford Medial Unicompartamental Knee Replacement. *J Bone Jt Surg Am* 2019;101(3):270–275.
32. **Inoue S, Akagi M, Asada S, Mori S, Zaima H, Hashida M.** The Valgus Inclination of the Tibial Component Increases the Risk of Medial Tibial Condylar Fractures in Unicompartamental Knee Arthroplasty. *J Arthroplasty* [Internet] Elsevier Ltd, 2016;31(9):2025–2030.
33. **Deschamps G, Chol C.** Fixed-bearing unicompartamental knee arthroplasty. Patients' selection and operative technique. *Orthop Traumatol Surg Res* 2011;97(6):648–661.
34. **Sekiguchi K, Nakamura S, Kuriyama S, Nishitani K, Ito H, Tanaka Y, Watanabe M MS.** Effect of tibial component alignment on knee kinematics and ligament tension in medial unicompartamental knee arthroplasty. *Bone Jt Res* 2019;8(3):126–135.
35. **Rivière C, Harman C, Leong A, Cobb J, Maillot C.** Kinematic alignment technique for medial OXFORD UKA: An in-silico study. *Orthop Traumatol Surg Res* 2019;105(1):63–70.
36. **Dai X, Fang J, Jiang L, Xiong Y, Zhang M, Zhu S.** How does the inclination of the tibial component matter? A three-dimensional finite element analysis of medial mobile-bearing unicompartamental arthroplasty. *Knee* 2018;25(3):434–444.
37. **Biomet Z.** Oxford phase 3-Oxford™ unicompartamental knee manual of the surgical technique.
38. **Clarius M, Hauck C, Seeger JB, Pritsch M, Merle C AP.** Correlation of positioning and clinical results in Oxford UKA. *Int Orthop* 2010;34(8):1145–51.
39. **Yokoyama M, Nakamura Y, Egusa M, Doi H, Onishi T, Hirano K, et al.** Factors related to stress fracture after unicompartamental knee arthroplasty. *Asia-Pacific J Sport Med Arthrosc Rehabil Technol* [Internet] Asia-Pacific Knee, Arthroscopy and Sports Medicine Society, 2019 [cited 21 Jul 2019];15:1–5.

Figure Legends

Fig. 1. Medial eminence line (MEL) and classification of tibial morphology. The tibial axis (TA) is defined as a line passes the center point of the tibial width at 6 and 12 cm below the joint line. MEL is defined as a line parallel to the TA and passing the tip of medial intercondylar eminence. If the MEL passes medial to the medial cortex of the tibia, the tibia is classified as “Intramedurally type”. Otherwise, the MEL goes medial to the medial cortex and is classified as “Extramedurally type” (right).

Fig. 2. The take-off sign. Before a complete fracture, the medial shift of the tibial component that shows a minor separation between lateral surface of bone (the vertical cut and keel slot plane), and medial surface of the implant (arrowheads). This sign normally appears at one to two weeks postoperatively, followed by a complete fracture 2 to 4 weeks. This separation might be prevented by the cement holding the bone together.

Fig 3. The effect of varus implantation of a tibial component with tibia vara. The recommended position (solid tibial tray outline) is perpendicular to the mechanical axis of the tibia. The varus component (dotted tibial tray outline) could be a larger size and the keel is further from the medial cortex.