CT 스캔 가상 재건술을 이용한 근위경골절골술의 상호교정각에 따른 후방경사각 변화

The Variation of Posterior Slope Angle by Co-correction Angles on the High Tibial Osteotomy (HTO) using CT Scan Reconstruction Virtual Surgery

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1. Opening Wedge High Tibial Osteotomy

The radiographs of all pelvic limb to evaluate the alignment of the pelvic limb in 1970 were so difficult and their accuracy also became a problem. At that time, the tibiofemoral angle just by the anterior/posterior radiographs of the knee was tried to correct and the concept of 7°+ was set up. After the effective pressures on the medial/lateral and anterior/posterior of the knee were measured accurately during the weight-loading to consider the alignment of all pelvic limb, one of the orthopedist's wishes was to get the information of the reasonable osteotomy to consider the dynamic pressure change during walking, that was to decrease the pressure at the clinical change part when real-walking and to prevent the transfer the excessive pressure to the opposite part. In the case of High Tibial Osteotomy (HTO), after the merit and the weakness of both Opening Wedge Osteotomy (OWO) and Closed Wedge Osteotomy (CWO) were co-existed, OWO becomes the current trend. Moreover, the treatment of the medial collateral ligament during HTO was not solved yet. The patients number of HTO, which was the real operation of the translated knee ailment, is being decreased by the artificial transplant of the knee such as Total Knee Arthroplasty (TKA). During TKA, Anterior Cruciate Ligament (ACL) was removed. When it was working for a long time, many problems such as the loosening of the artificial bone, the insensibility of the distal femur and proximal tibia, the stiffness of the hyper knee flex, the friction noise from the metal to metal, were existed. Since the failure of the artificial transplant was inevitable for the high active patient or the special patient to have the axial dislocation from the bone, it was not believed that it was permanent. HTO is the operation to correct the malalignment by the anatomic axis dislocation from the femur and the tibia (See Fig.1(d)). This operation is to prevent the degenerate arthritis by the distribution of the abnormal excessive loading from the medial tibial plateau to the lateral tibial plateau.[1,2] Therefore, our research group performed the computation aided virtual osteotomy using the reconstruction of 3-D CT images. Shown in Fig. 1(d), Upper Tibial Open Wedge Osteotomy (UTOWO) increases the anterior oblique angle during the re-alignment of the anatomical axis and it also increases the posterior slope. Since it results in the increase of the ACL tension, the rupture possibility of ACL is greatly increased during the sports activity.[3] Frank *et. als*.[4] studied the effect of the oblique angle and the wedge angle on the posterior slope angle by the clinical approach but it was restricted in the 90° of the hinge axis angle. Nowadays, the postero-lateral hinge axis osteotomy, where the hinge axis angle was 45°, becomes the standard so Frank's study has the limitation to apply UTOWO. Moreover, the results were verified by the computation aided virtual osteotomy. The parameters to affect the increase of the posterior slope angle, were not only the hinge axis angle, the gap angle but also the oblique angle and the wedge angle. For this reason, it the co-relationship of the above 4 angles were defined, it is believed that the bio-mechanical approach to the osteotomy is even clearer.

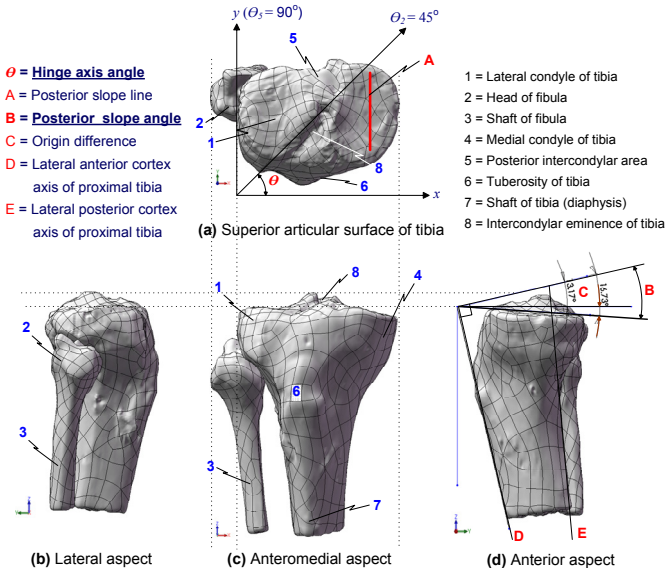


Fig. 1 Terminologies of the proximal tibia using CT scan reconstruction (superior, anteromedial and lateral aspects)

2. Development of X-type Fixation Plate

The operation of Upper Tibial Open Wedge Osteotomy (UTOWO) to cure the malalignment and the degenerate arthritis, is easier than that of Upper Tibial Closed Wedge Osteotomy (UTCWO).

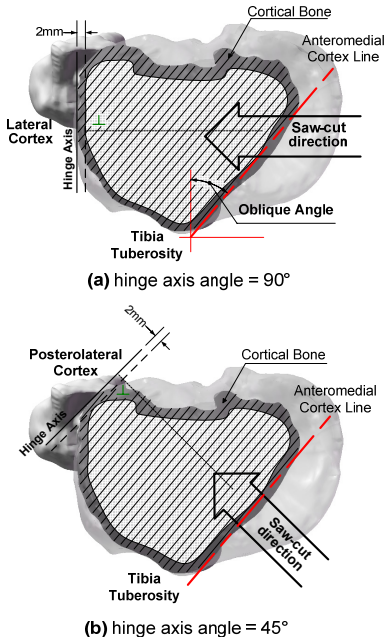


Fig. 2 Relationship between hinge axis angle = 90° versus hinge axis angle = 90° in high tibial osteotomy

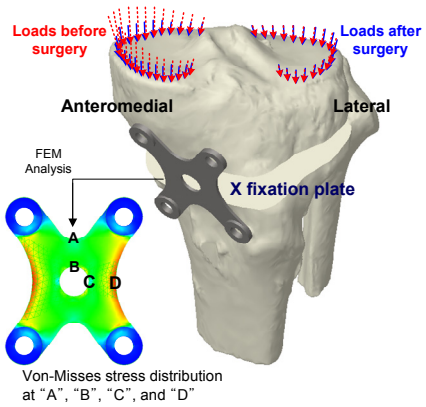


Fig. 3 Stress distributions at the point "A", "B", "C", and "D", respectively in X type fixation plate

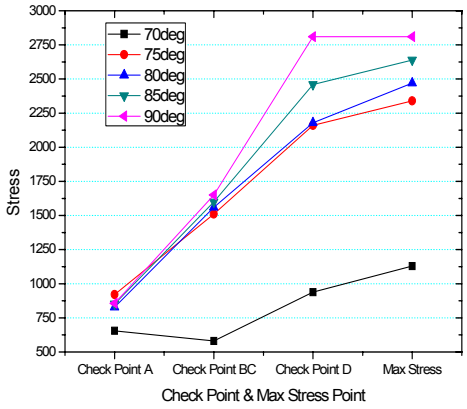
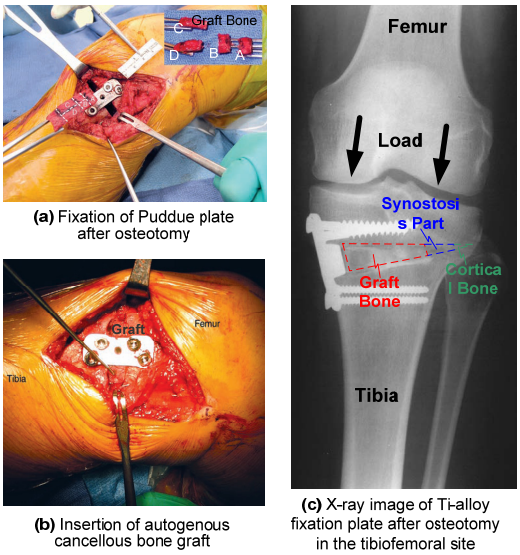


Fig. 4 Stress value of five different plate angles at the check point A, B, C, D and max. stress, respectively

In addition to this advantage, since the UTOWO did not cause the intraoperating damage of the proximal tibiofibula. It is the effective surgery technique to keep the penoneal nerve. To minimize the deformation of the upper tibia, the shortness of the lower limb can also be prevented. UTOWO is one of the surgery techniques to transfer the overload of the medial meniscus by the genu varum to the lateral meniscus by the translation of the anatomical axis and uniformly distributes the stress, which is transferred from the trunk to the tibia along the axial direction of the femur, to the mediolateral menuscus. Considering the mechanical view, the supporting axis of the lower limb is the line to connect the center of the hip joint with the center of the tibiotalar joint. The connecting line is located inside the center of the knee joint and is deviated from about 4±2mm. If the mechanical axis is deviated medially or laterally, the genu varum deviation or the genu valgum deviation can be happened. If the supporting axis proceeds over 15mm from the centre of the knee joint medially or over 10mm laterally, the genu varum deviation or the genu valgum deviation is severely appeared.[5] To view from the lateral surface, tibia plateau is a little bit moved to the back rather than the axis of the femur and about 10° of articular surface in the tibia is angled down. This angle is called the Posterior Slope Angle (PSA) and it is the most important to keep PSA normal during UTOWO to correct the genu varum. However, the angle of the open wedge aperture by the cut of the proximal tibia after the osteotomy, can be changed by the walking/acting of the postoperated patient. After it results in the change of the PSA and the tibial spine deformation of the anatomical axis, the second malalignment and the unstable ligaments can be caused (See Fig.2). Comparing with the exact angle of UTOWO, the maintenance of the open wedge aperture in the proximal upper tibia,



(a) Fixation of Puddue plate after osteotomy

(b) Insertion of autogenous cancellous bone graft

(c) X-ray image of Ti-alloy fixation plate after osteotomy in the tibiofemoral site

Fig. 5 Insertion of Puddue fixation plate and autogenous cancellous bone graft

which is caused by the deformation of the anatomical axis after the osteotomy, is also very important. At this time, the metal plate is used to keep the open wedge aperture (See Fig.3). If the bone condition of the tibia is normal, the open wedge aperture can be maintained without the special operation to fix it after the osteotomy of 13mm using the metal plate. If the height of the open wedge aperture is over 13mm, it is filled with the autogenous cancellous bone graft, which is collected from the patient. This filled aperture makes it possible to avoid the fibular excision, the open of the peroneal nerve, the detachment of the extension muscle, the shortness of the lower limb and so on. For the planted autogenous cancellous bone graft to make the perfect synostosis of the upper and lower tibia, 13.2weeks on average is needed. If the delayed union by the inhalation of nicotine happens, about 25weeks is required. Based on the Puddue plate and the Tomofix plate, which is the representative fixations metal plate, the design condition and the stress evaluation, the new metal plate for the osteotomy was designed in this study. Our suggested model is the X-type fixation plate for the osteotomy, which cures the existing hallux valgus and the flat foot. Its shape is deformed and applied for the high tibia osteotomy.

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