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Tibial Plafond Deformity Characteristics in Ankle Osteoarthritis using Three-Dimensional Geometric Analysis

Y. Oishi, H. Kurokawa, S. Kosugi, Y. Tanaka, Y. Ishige, M. Yamamoto and H. Takemura

Abstract— **The etiology of primary ankle osteoarthritis is not enough elucidated. X-ray images and Computed Tomography (CT)-scan images are usually used for the classification of ankle osteoarthritis (OA), however, the classification by the 2D measurements of the X-ray images and CT images can vary between physicians. The aim of this study is the 3D geometrical deformity characteristics quantitative evaluation of the tibial plafond according to the ankle OA classification. The 3D geometric statistical analysis was conducted for the 18 ankle OA feet. Although the 3D analysis results in tibial plafond have not been shown consistent deformity along with the progress of ankle OA, the deformity characteristics of high severity ankle OA revealed.**

Clinical Relevance— **This bone analysis helps to reveal 3-D deformity features to assist doctors in the plan of new treatments for ankle OA.**

I. INTRODUCTION

The etiology of primary ankle OA is not well elucidated. The knowledge of the underlying etiology is essential in trying the appropriate surgery for ankle OA. A two-dimensional analysis was used to be conducted from X-ray images or CT images on ankle OA. Ankle OA has been classified into four levels and five types according to Takakura and Tanaka's Classification (TTC) [1]. However, 2D analysis by humans has some problems that depend on the clinician's subjective judgment criteria. Therefore, 3D analysis is pretty essential. The 3D bone analysis is widely applied, but 3D bone analysis for OA is scarce on ankle OA. The purpose of this study is to characterize the 3D geometric deformation of the tibial plafond according to the classification of ankle OA.

II. METHODS

The study population consisted of twelve females with ankle OA (18 feet: 10 right, 8 left, aged 69.3 ± 6.5 years). Ankle OA patients were classified into four stages and five types (stage 1, 2, 3A, 3B ,4) using TTC [1]. In this study, the images of the foot were captured using a CT scanner (Optimal CT 600, GE Healthcare Inc). The subjects were the supine position during CT acquisition. In addition, a medical compressor (DynaWell® loading device) was used for the subjects assume that ankle joint loading in stance position. The data obtained by CT were mostly radiation transmission images. The volume registration method was used to quantify the bone shape in each subject [2]. The volume registration method associated similar parts by calculating a deformation field that minimized the luminance error of the two volumes.

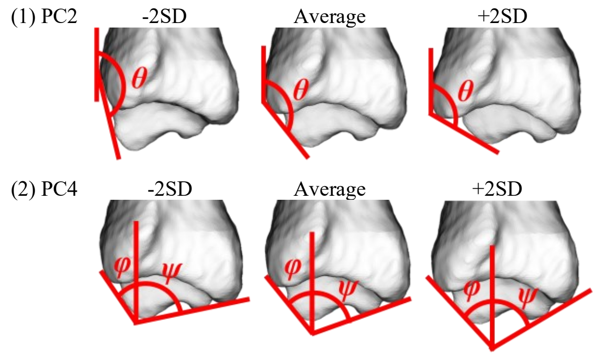

Fig. 1 Bone shape for principal component in ankle osteoarthritis. The red theta in Fig. 1(1) represented bone shape deformity characteristics from - twice Standard Deviation (-2SD) to +2SD in 2nd PC. The red phi and psi in Fig.1(2) represented bone shape deformity characteristics from -2SD to +2SD in 4PC. Statistically significant differences were found in the hyperostosis of edge of anterior tibial plafond (PC2) between stage 3B and mild group ($p < 0.004$) and the hyperostosis of medial malleolus (PC4) between stage 4 and mild group ($p < 0.002$).

principal component analysis was performed on the values of the bone shape deformity quantified by the volume registration method.

III. RESULTS

The cumulative contribution rate exceeded 80 % up to the sixth principal component (PC), so PCs to sixth were created. In the 2nd PC, a statistically significant difference ($p<0.004$) was found between stage 4 and the mild group (normal and stage 1, 2). In the 4th PC, a statistically significant difference ($p<0.002$) was found between stage 3B and the mild group. The bone deformities were showed in Fig. 1.

IV. DISCUSSION & CONCLUSION

In this study, 3D statistical analysis was performed by using principal component analysis for the tibial plafond with ankle OA. The analysis results suggested that the different deformity features were present in patients with more severe disease. This study contributes us to investigate the deformity characteristics of ankle OA that 2D analysis cannot reveal.

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Yuya Oishi is with the Tokyo University of Science National Institute of Standards and Technology, Boulder, 2641, Yamazaki, Noda, Chiba, Japan (corresponding author to provide phone: 04-7124-1501 (3931); fax: 04-7123-9814; e-mail: 7520509@ ed.tus.ac.jp)

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