MEDS Clinical Medicine (2021) 2: 82-85
Clausius Scientific Press, Canada

DOI: 10.23977/medsc.2021.020216
ISSN 2616-1907

Study on the difference of tibial osteotomy coverage between symmetric and asymmetric prosthesis in total knee arthroplasty by 3D simulation technology

Jichao Hu[1, a], Cheng Jin[2, b], Wang Zheng[3, c]

[1]Department of Orthopedic Surgery, Zhejiang Province Rongjun Hospital, Jiaxing, 314001, China

[2]Department of Orthopedic Surgery, Zhoushan Hospital, Zhejiang University School of Medicine, Zhoushan, China

[3]Department of Basic Medicine, School of Medicine, Jiaxing University, 118 Jiahang Road, Jiaxing, Zhejiang 314001, China

[a]40565018@qq.com, [b]jin1024zy@126.com, [c]zhengw0907@163.com

Keywords: 3D simulation, total knee arthroplasty, symmetrical and asymmetrical prosthesis, tibial osteotomy coverage

Abstract: **Objective:** To study the difference of tibial osteotomy coverage between symmetrical prosthesis and asymmetrical prosthesis, and to further demonstrate the necessity of designing asymmetrical prosthesis and anatomical prosthesis. **Methods:** 3D simulation technology was used to simulate the operation to obtain the parameters of tibial osteotomy surface of each patient, and five kinds of prosthesis were used for optimal coverage. Finally, the coverage difference of tibial osteotomy surface of each prosthesis was analyzed. **Conclusion:** 3D simulation technology is an important means to study tibial osteotomy surface, which is worthy of further promotion and research.

1. Introduction

Knee joint is the largest joint in human body with complex anatomical structure and high functional requirements. With the aging era, osteoarthritis patients gradually increase, including the incidence rate of knee osteoarthritis. Total knee arthroplasty (TKA) has become a routine method for the treatment of advanced knee osteoarthritis. Intraoperative prosthesis and tibial osteotomy surface matching is the key factor for the success of TKA. By increasing the coverage of prosthesis on tibial osteotomy surface, the load of single area of prosthesis can be reduced, and then the wear of polyethylene block can be reduced, the stability of prosthesis can be increased, the subsidence and loosening of prosthesis can be delayed, and the life of prosthesis can be further extended.

Anatomically, the tibial plateau of normal people is asymmetric, and the medial side is significantly larger than the lateral side, so the tibial prosthesis should also be asymmetric. With the development of medical technology, there are more and more types of prostheses for doctors, but most of them are symmetrical (the size of the inside and outside is the same), and only a few tibial prostheses are asymmetric (the inside is larger than the outside). The biggest disadvantage of symmetrical prosthesis is that the coverage of medial platform is significantly lower than that of

lateral platform, especially the posterior side of medial platform. If the size of the prosthesis is selected according to the size of the medial platform, the prosthesis obviously exceeds the osteotomy surface of the lateral platform, resulting in uneven coverage of the medial and lateral sides, increasing the stress on the osteotomy surface, and the excess part stimulates the posterior soft tissue, causing corresponding symptoms.

At present, there are many researches on knee joint morphology at home and abroad, including the anatomical differences between Asian and European, male and female, as well as the anatomical differences between the internal and external tibial plateau, and most of these research objects are normal people. [1] There are few researches on the morphology of patients with osteoarthritis, and in TKA, symmetrical prosthesis and asymmetric prosthesis, the comparative study of tibial osteotomy coverage is less.

In this study, 3D simulation technology was used to obtain the anatomical parameters of patients who actually accepted TKA, and five kinds of prostheses (three symmetrical prostheses and two asymmetrical prostheses) were used in the market to simulate the operation on the special robot assisted computer system for orthopedic surgery. So as to study the difference of tibial osteotomy coverage between symmetrical prosthesis and asymmetrical prosthesis, it is necessary to design asymmetric prosthesis and anatomic prosthesis. [2] Although 3D simulation and printing technology is developing rapidly, it is unable to produce individual designed prosthesis. However, according to preoperative simulation surgery, it can provide correct basis for clinical selection of prosthesis which is most suitable for patients' anatomical shape, and provide anatomic parameters for the design of domestic anatomical prosthesis in the future.

2. Research method

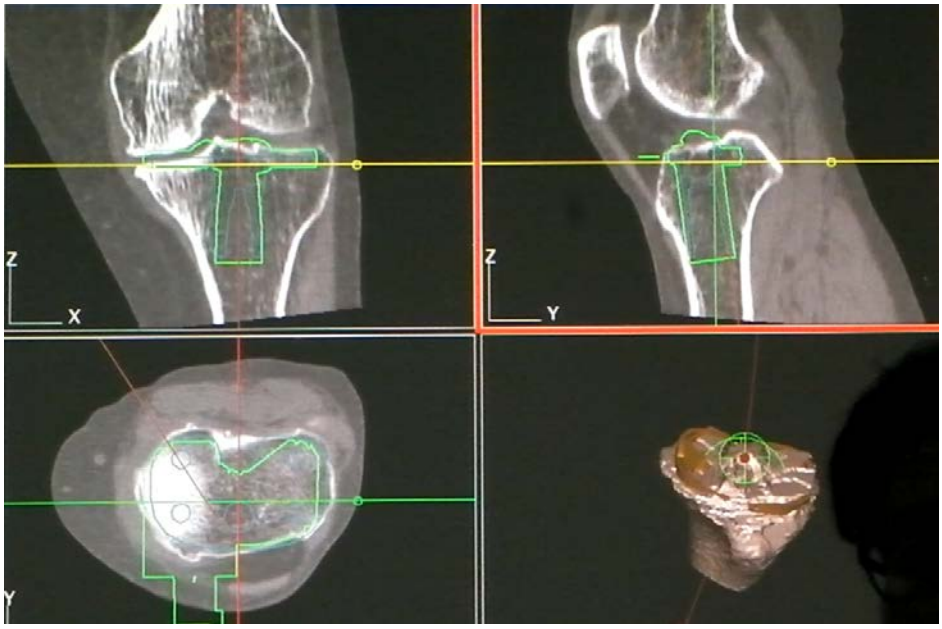

Figure 1: Simulation operation on computer system of orthopedic surgical robot

We selected 200 patients with knee osteoarthritis who received TKA in our hospital and two project cooperation hospitals from June 2018 to October 2019 due to knee osteoarthritis. Computed tomography (CT) was routinely performed in each patient before operation, and the data was uploaded to the special robot assisted computer system for orthopedic surgery to obtain a 1:1 three-dimensional reconstruction model with the patient's anatomical shape for preoperative simulation

operation. According to the simulated operation, the tibial osteotomy surface parameters of each patient were obtained, and five kinds of prosthesis were used for the best coverage. Finally, the coverage difference of each prosthesis on the tibial osteotomy surface was analyzed, as shown in Fig.1.

The simulated operation is very similar to the actual clinical operation. During the operation, the rotation center of prosthesis and the thickness of osteotomy can be adjusted repeatedly. In the actual TKA, the matching degree of prosthesis and osteotomy surface was shown in tibial plateau, medial posterior, lateral posterior and medial lateral. The optimal position of the prosthesis in the simulated operation is determined. The coverage of the prosthesis in the above three parts is compared, and the overall coverage area of the osteotomy surface is compared, as shown in Fig. 2.

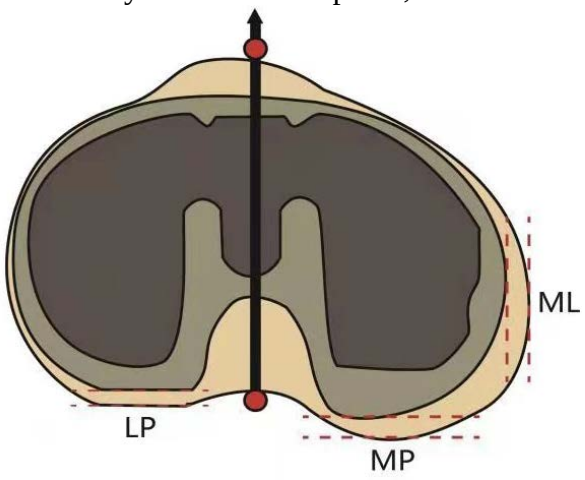

Figure 2: Schematic diagram of coverage measurement between and between prostheses on tibial osteotomy surface

3. Technology Roadmap

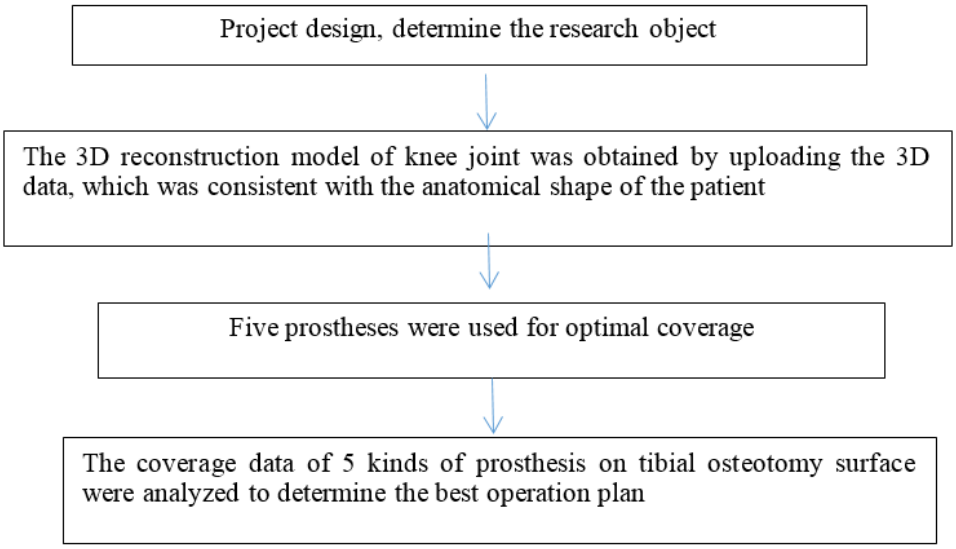

Figure 3

The 3D simulation technology we use is a special robot assisted computer system for orthopedic surgery, with an accuracy of 0.2mm. The patients we studied were patients who actually received

TKA, and the parameters of tibial osteotomy surface obtained were very close to the actual clinical osteotomy surface. Moreover, we used five kinds of prosthesis on the same osteotomy surface, so it can better reflect the difference of tibial osteotomy surface coverage between prosthesis.

4. Conclusion

In recent years, with the rapid development of 3D simulation technology, this technology is widely used in the field of medicine. It can supplement the traditional two-dimensional medical images with dynamic three-dimensional images, and reconstruct three-dimensional images with continuous sectional images; It can accurately display the complex three-dimensional structure of biological tissue, and observe and operate arbitrarily; It can measure the reconstructed three-dimensional structure and obtain a large number of accurate anatomical parameters such as length, area, volume and angle; It can be used in operation design and operation simulation, so it is also called "virtual anatomy technology".

Virtual anatomy is a new non-invasive "Anatomy" technology. It uses imaging technology to construct three-dimensional images of human organs and tissues, which can truly reflect the anatomical structure and actual size of bones, and provide rich bone image information. The technology is practical and effective, comprehensive measurement and simple operation; The measurement data has the advantages of small error, high accuracy, stability and reliability, and a large amount of data can be obtained directly from the living body. 3D simulation technology can not only restore the real human anatomy, but also cut any anatomical part and analyze the relevant parameters. Because the virtual anatomical measurement is more direct and the data obtained is more accurate, it can be used to measure large samples. Finally, the digital analysis method is used to calculate the obtained anatomical parameters repeatedly, so as to completely reduce the dissection segmentation of real cadaver specimens.

At present, in Europe and the United States, some doctors and prosthetic companies use this technology to repeatedly test and analyze, obtain the correct anatomical parameters, and design non symmetrical prostheses such as Genesis II (Smith & nephew), emotion pro (B-Braun), persona (Zimmer) that conform to the anatomical morphology of European and American, and apply them in clinic. This study also provides ideas and methods for 3D simulation technology of tibial osteotomy surface coverage. [3-4]

Acknowledgements

Funding Support:
Jiaxing Science and technology project, 2018AD32164
Zhejiang basic public welfare research project, LGF20H170010

References

[1] Yue B, Varadarajan KM, Ai S, et al. Differences of Knee Anthropometry between Chinese and White Men and Women. J arthroplasty 2011; 26(1): 124.
[2] Wernecke GC, Harris IA, Houang MT, et al. Comparison of tibial bone coverage of 6 knee prostheses: a magnetic resonance imaging study with controlled rotation. J Orthop Surg (Hong Kong) 2012; 20(2): 143.
[3] Stulberg SD, Goyal N. Which Tibial Tray Design Achieves Maximum Coverage and Ideal Rotation: Anatomic, Symmetric, or Asymmetric? An MRI-based study. J Arthroplasty. 2015 Oct; 30(10): 1839.
[4] Jin C, Song EK, Prakash J, et al. How Much Does the Anatomical Tibial Component Improve the Bony Coverage in Total Knee Arthroplasty? J Arthroplasty. 2017 Jun; 32(6): 1829.