HURWA Robotic-Assisted TKA System is Suitable for a Variety of Prosthesis Types

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Abstract

Background

Total knee arthroplasty (TKA) is an effective and also mature surgical interventions that improves life quality and provides pain relief. Accurate bone cuts are important to prevent TKA malalignment and it requires cautious preoperative plan and precise bone resection. Recently, robotic-assisted TKA techniques have been used to improve the accuracy of bone resection and implantation. However, the system described above suits for only one prosthesis type.

Methods

Five types (MicroPort_CS, Smith& Nephew_GII, Johnson&Johnson_PFC_PS, kingnow _VLQX_PS and Akmedical_A3GT_PS) implants were included in our study and three Sawbones models were used for each implant. Procedures were performed by experienced joint replacement surgeons using HURWA robotic-assisted TKA system.

Results

our study indicated that the bone resection error of HURWA robotic-assisted system was below 0.5 mm (with SDs below 0.3 mm), and all of the bone resection angles were below 0.5° (with SDs below 0.3°). The bone resection angles and levels deviation of different brand prosthesis types were below 0.5 mm (with SDs below 0.3 mm) and below 0.5° (with SDs below 0.3°) respectively.

Conclusion

It suggested that our system may be suitable for different prosthesis types.

Introduction

Knee osteoarthritis, a complicated joint disorder, is the most common joint disorder and its prevalence is growing around the world^{1,2}. Total knee arthroplasty (TKA) is an effective and also mature surgical interventions that improves life quality and provides pain relief³. TKA is used for treating severe osteoarthritis when nonsurgical treatment fails⁴. However, the satisfaction rate among TKA patient ranges from about 75–89% by using different clinical outcome calculations^{5–7}. About 4.4% of cases who underwent primary TKA needs revision surgeries within ten years⁸. Accurate bone cuts are important to prevent TKA malalignment and it requires cautious preoperative plan and precise bone resection.

TKAs are traditionally carried out by using mechanical instruments and tools such as intramedullary canal rods, mechanical blocks, hand-held power tools and extramedullary jigs^{9,10}. However, its inaccuracy increases polyethylene wear and revision rates^{11,12}. Recently, robotic-assisted TKA techniques have been used to improve the accuracy of bone resection and implantation^{13–15}. For example, Blum et al. demonstrated that

OMNIBotics TKA system can improve KOOS scores compared to a large contemporary database¹⁶. Mitchell and their colleagues reported that robotic-assisted TKA decreased the length of stay, morphine consumption, 30-day readmission rates and physical therapy visits¹⁷. However, the system described above suits for only one prosthesis type.

Our previous studies showed that the safety and accuracy of HURWA TKA system in a sheep model is reliable and it may be suitable for TKA in human¹⁸. Furthermore, we demonstrated that errors of bone resection angles and levels were all below 0.6 mm using our system¹⁹. The aim of our study is to demonstrate that whether our system is compatible to different prosthesis types.

Materials And Methods

Study design

Five types (MicroPort_CS, Smith& Nephew_GII, Johnson&Johnson_PFC_PS, kingnow _VLQX_PS and Akmedical_A3GT_PS) implants were included in our study and three Sawbones models were used for each implant. Procedures were performed by experienced joint replacement surgeons using HURWA robotic-assisted TKA system.

Preoperative planning and Robotic-assisted TKA procedure

Preoperative plans were set up by surgeons according to the anatomy references of knee Sawbones CT data. Robotic-assisted TKAs were performed following the plan. In brief, surgeons resect the bone assisted by the robotic arm guided by registered femoral and tibial landmarks.

Bone resection analysis

Sawboneses were measured by the structured light scanning device (EinScan Pro 2X Plus, Hangzhou, Zhejiang). The sagittal and coronal of both tibial and femoral postresection measurements were noted. The difference between the plan and postresection measurements were measured.

Statistical analysis

Results were indicated as the mean $\pm$ SD (standard deviation). One-way analysis of variance was used to determine the difference between the groups. P Values <0.05 was considered. statistically significant. Statistical assay was performed by SPSS.

Results

Bone resection levels and angles

The difference between the postresection measurements and plans for bone resection were indicated in Table 1. The total levels accuracy of all groups of bone resection was below 0.5 mm (SD below 0.3 mm) and the total angles of bone resection were below 0.5° (with SDs below 0.3°). Moreover, the levels accuracy of Smith& Nephew_GII group were below 0.5° (with SDs below 0.2°) and the total angles of bone resection were below 0.6° (with SDs below 0.3°). the levels accuracy of MicroPort_CS, Johnson&Johnson_PFC_PS, kingnow

_VLQX_PS and Akmedical_A3GT_PS group were below 0.5° (with SDs below 0.2°), below 0.5° (with SDs below 0.3°), below 0.5° (with SDs below 0.3°) and below 0.4° (with SDs below 0.2°) respectively and the angle of bone resection were below 0.6° (with SDs below 0.4°), below 0.5° (with SDs below 0.2°), below 0.5° (with SDs below 0.2°), below 0.5° (with SDs below 0.2°) and below 0.2° (with SDs below 0.2°). The bone resection accuracy of different brand prosthesis types was showed in Figure 1-5.

Discussion

In our study, we demonstrated that the bone resection error of HURWA robotic-assisted system was below 0.5 mm (with SDs below 0.3 mm), and all of the bone resection angles were below 0.5° (with SDs below 0.3°). The results were in line with our previous studies and it is more accurate than conventional techniques¹⁹.

Moreover, the accuracy of bone resection levels for Smith& Nephew_GII, MicroPort_CS, Johnson&Johnson_PFC_PS, kingnow _VLQX_PS and Akmedical_A3GT_PS group were below 0.5 mm (SD below 0.3 mm), below 0.5° (with SDs below 0.2°), below 0.5° (with SDs below 0.3°), below 0.5° (with SDs below 0.3°) and below 0.4° (with SDs below 0.2°) respectively and the angle of bone resection were below 0.5° (with SDs below 0.2°), below 0.6° (with SDs below 0.4°), below 0.5° (with SDs below 0.2°), below 0.5° (with SDs below 0.2°), below 0.5° (with SDs below 0.2°) and below 0.2° (with SDs below 0.2°). These data suggested that HURWA robotic-assisted TKA system is suitable for a variety of prosthesis types.

Recently, a growing number of robotic-assisted TKA systems have been applied to TKA clinical settings. For example, Khan et al. showed that Robotic TKA systems decreased blood transfusion rate and blood loss²⁰. Marchand et al. demonstrated that robotic-assisted TKA significantly improved postoperative outcomes such as pain, physical function and total score²¹. Deckey et al. showed that robotic-assisted TKA significantly improved precision and accuracy in planning both the final polyethylene inserts thickness and component positioning²². However, another study found that there were no differences between postoperative pain score in conventional TKA group and robotic-assisted TKA group, but these patients of robotic-assisted TKA group showed other benefits such as earlier discharge and discharged home²³. Held et al. showed that robotic-assisted TKA can improve the balancing of intraoperative compartment in flexion but not in extension and mid-flexion compared to conventional group²⁴. Our previous study also demonstrated that HURWA robotic-assisted TKA system can improve bone resection angles and levels accuracy in the Sawbones model. These data suggested that robotic-assisted TKA improves reproducibility and precision of the bone resection and implantation.

However, most of robotic-assisted TKA systems is compatible for only one prosthesis type. For instance, MAKO robotic-assisted TKA system can only be used for Stryker prosthesis, ROSA robotic-assisted TKA system only can be performed for Zimmer prosthesis, and NAVIO semi-active handheld robotic-assisted TKA system can only be used for Smith & Nephew prosthesis. One exception is TSolution One TKA system, which is open for many prostheses. There are many knee prostheses manufacturers such as Zimmer, Stryker, Smith & Nephew, Depuy and Biomet, and there are even more brands of prostheses in China such as XX. The diversity of the market calls for robotic-assisted TKA systems that is suitable for different TKA prostheses. Our data suggested that HURWA robotic-assisted TKA system may be suitable for multiple brands of TKA prostheses.

In conclusion, our study indicated that the bone resection error of HURWA robotic-assisted system was below 0.5 mm (with SDs below 0.3 mm), and all of the bone resection angles were below 0.5° (with SDs below 0.3°). The bone resection angles and levels deviation of different brand prosthesis types were below 0.5 mm (with SDs below 0.3 mm) and below 0.5° (with SDs below 0.3°) respectively. It suggested that our system may be suitable for different prosthesis types.

Abbreviations

TKA Total knee arthroplasty

CT Computed Tomography

Declarations

Acknowledgements

Not Applicable.

Authors' contributions

XY L, Z L, XF Z, LL D, J Y, SG L

conducted this study, and XY L and Z L wrote the manuscript. XY L and Z L, and SG L advised the interpretation of data and the constitution of the study. XY L and Z L analyzed the data. All authors have read and approved the final manuscript.

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

Not Applicable.

Consent for publication

Not Applicable

Competing interests

All authors declare they have no conflict of interest and competing interests.

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Figures

Figure 1

Typical picture of sawbones after bone resection of Smith& Nephew_GII.

Figure 2

Typical picture of sawbones after bone resection of Johnson&Johnson_PFC_PS.

Figure 3

Typical picture of sawbones after bone resection of MicroPort_CS.

Figure 4

Typical picture of sawbones after bone resection of kingnow _VLQX_PS.

Figure 5

Typical picture of sawbones after bone resection of Akmedical_A3GT_PS.