Poster Presentation

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Design of Cement Articulating Spacer Silicone Mold from Rapid Prototype Model

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Abstract

The patient with the knee arthrosis was treated by replace the total knee prosthesis at the knee joint but they had a chance to infect after the surgery. After infection, the surgeon had to re-implant with the antibiotic cement, which was made by the surgeon's handmade that effect to the patient to take a long time in the surgery. This research aims to use the reverse engineering process and rapid prototype model to construct the custom-made articulating spacer for the patient by using the silicone mold and to compare with the ABS mold in the previous study. The result was shown the best fit to femur and tibia bone model that had a smooth surface and easy to remove from the mold. The silicone mold will help the surgeon to reduce time during the surgery's process and to reduce cost from the sterile process. The short period in the surgery will help the patient to take less time for recuperate from the surgery and return to the normal activities.

Keywords: Cement Articulating Spacer, Silicone Mold and Rapid Prototype Model.

1. Introduction

Knee joint was a complex and the biggest joint in the human body, was used for motion and transferred the bodyweight to the foot. The knee arthrosis as shown in Fig. 1 was the main reason to disorder the joint function that had the effect to the human motion. Treatment of knee arthrosis was divided in two methods as surgery for the high damage and non-surgery for low damage joint.

Fig.1 Arthritis of knee joint [1]

Total knee arthroplasty (TKA) was a successful surgery procedure to treat the patient with the knee arthrosis to relieve the pain and restore the function of knee joint [2] but this treatment had the chance to infect at the patient knee. Revision surgery of infected TKA was challenge for the surgeon and the result of inferior outcome had compared with the primary TKA [3]. The infection had treated by surgery and non-surgery method. The surgery method had reported with high successful rate around 90-96% [4]. The 2-stage re-implantation the antibiotic cement spacer in infected total knee arthroplasty had been separated in two types as static and articulating spacer. Comparison of static and articulating spacer had reported 14% of static group and 9% of articulating group to recurrence of infection with original organism [4-7] but the articulating spacer had better knee score, less bone loss and range of motion.

This research aims to design the antibiotic cement spacer mold from computer aided design and to construct the silicone mold for the surgeon to use in the surgery process. The articulating spacer mold will be help the surgeon to reduce the time during the surgery process and the patient will be spend less time to recuperate.

2. Materials and Methods

2.1 Three-dimensional Bone Models

The lower extremity was scanned by computerized tomography (CT) scanner to collect the data of distal femur and proximal tibia for design the custom made model of femoral and tibia component of total knee prosthesis by computer aided design. The CT data was shown in Fig. 2.

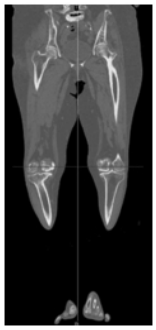

Fig. 2 CT slices data of lower extremity

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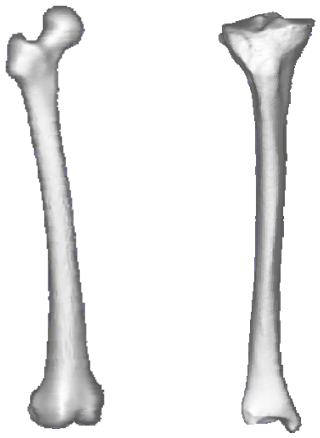
Three-dimensional model of femur and tibia were converted from the CT data by ITK-SNAP software as shown in Fig. 3 and were imported to the SolidWorks software for reference the size and shape to design the femoral and tibial component of articulating spacer.

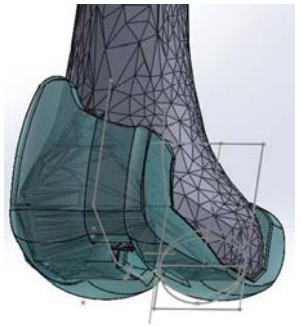


(a) (b)

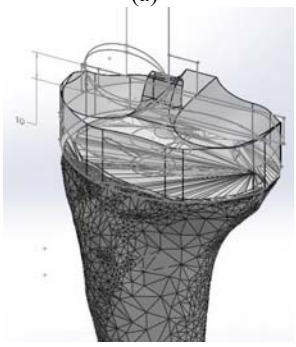
Fig. 3 Three-dimensional model: (a) Femur and (b) Tibia.

2.2 The Articulating Spacer Model

The articulating spacer was used the contour and shape of three-dimensional bone model to design as shown in Fig. 4 and the model was used to modify as the cavity to construct the part of mold as shown in Fig. 5.

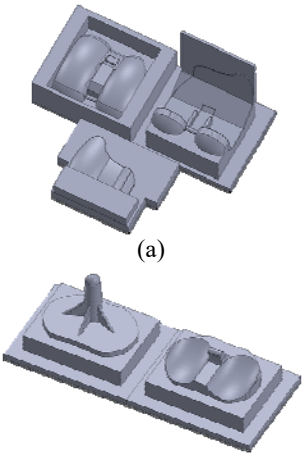


(a)



(b)

Fig. 4 The design of articulating spacer: (a) Femoral component and (b) Tibia component.



(a)

(b)

Fig. 5 CAD model: (a) Femoral component mold and (b) Tibia component mold.

The model was constructed by 3D printer, which printed the model from Acrylonitrile Butadiene Styrene (ABS) wire by heat the nozzle and the base. ABS was feed to construct the model layer by layer.

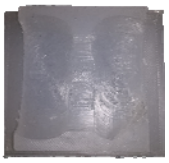
2.3 Silicone Mold

The silicone mold was made from two fluid materials to mix and fill in the box that put the ABS model below the box as shown in Fig. 6. The molds were separated to 3 parts for the femoral component and 2 parts for tibia component because the femoral component had the complex shape, which hardly define the parting line.

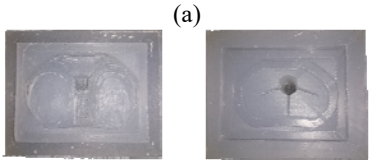
Fig. 6 The silicone mold.

3. Result

The silicone mold was shown in Fig. 7(a) for femoral component and 7(b) for tibia component.



(a)



(b)

Fig. 7 The silicone mold: (a) Femoral component and (b) Tibia component.

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This study was used resin to construct the articulating spacer model because of the limitation of budget to get the bone cement (Polymethylmethacrylate: PMMA). The resin was compounded from two liquids and set up in five minutes. The articulating spacer resin was shown in Fig. 8.

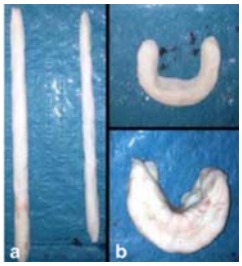
(a) (b)

Fig. 8 The articulating spacer resin from silicone mold: (a) Femoral component and (b) Tibia component.

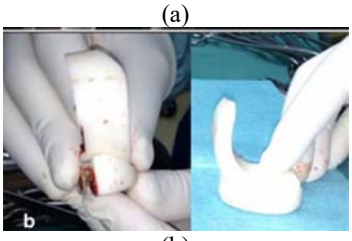
4. Discussion

4.1 Articulating Spacer

The articulating spacer resin from the silicone mold had smoother surface and proper shape than the handmade spacer model. The shape of handmade spacer model was depending on the surgeon's experience as shown in Fig. 9.



(a)



(b)

Fig. 9 The antibiotic-loaded cemented spacer: (a) Static spacer and (b) Dynamic spacer [8]

The femoral and tibia component were validated size and shape by insert at the distal femur and proximal tibia model same as the surgery process. The articulating spacer had fit to the bone and compare with the normal bone in Fig. 10 and 11 for femur and tibia respectively.

(a) (b)

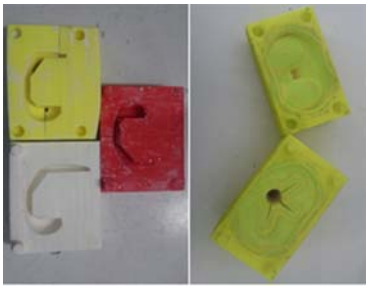
Fig. 10 Bone model: (a) Femoral bone and (b) Femoral bone inserted femoral component.

(a) (b)

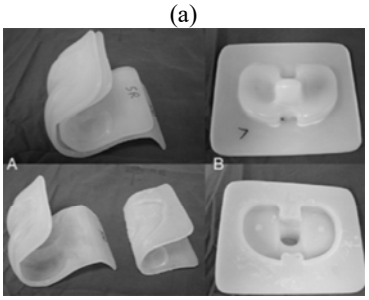
Fig. 11 Bone model: (a) Tibia bone and (b) Tibia bone inserted tibia component.

4.2 Articulating Spacer Mold

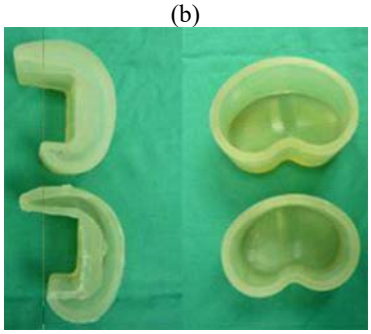
The articulating spacer mold had constructed from many materials such as acrylonitrile butadiene styrene (ABS) [9], polypropane [4] and silicone [10] that depended on the researcher as shown in Fig. 12. The silicone mold in this study is strong and easy to construct and remove the articulating spacer with the custom made shape to help the surgeon reduce the surgical time.



(a)



(b)



(c)

Fig. 12 Articulating spacer mold: (a) ABS mold [9], (b) Polypropane mold [4] and (c) Silicone mold [10]

5. Conclusion

This research was shown the method to construct the articulating spacer for the custom made model by reverse engineering and computer aided design. The results were shown the articulating spacer mold can help the surgeon to reduce the surgery time process and the articulating spacer from the mold had a best fit and good shape for the patient.

6. Acknowledgement

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