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Original article

The use of three-dimensional model construction of virtual technology in orthopedic treatment

Chenguang Li, Feng Xue, Fengxin Zhou *

Tianjin Nankai Hospital, Tianjin 300100, China

A R T I C L E   I N F O

A B S T R A C T

Objective: The objective of this study is to explore the construction of a digital three-dimensional model of virtual technology that plays an auxiliary role in orthopedic treatment.
Methods: Three fracture patients were selected, with no abnormality was observed in bone examination, no musculoskeletal disease in the past; and spiral CT scan of the spine and pelvis, upper limbs, and lower limbs was performed. The virtual technology was used to build a digital 3D model, mainly using the editing software Mimics10.0 software. In addition, the virtual three-dimensional model was verified by virtual surgery, data storage security, work efficiency of the model, model validity, three-dimensional characteristics of the model, the interaction mode of the model, and the data accuracy of the model were studied.
Results: The digital 3D model was successfully established by Mimics10.0 software. The data fitting efficiency was very high. The data storage security of the 3D model was greatly improved compared with the 2D model, and the work efficiency was improved by at least 50%. There was also a significant change in the accuracy and interaction of data acquisition. Therefore, the detection of digital 3D model work through virtual surgery simulation fully demonstrated the positive auxiliary role of 3D model in orthopedic treatment.
Conclusion: The digital 3D model based on Mimics10.0 software is efficient and accurate in obtaining data. It is very effective for subsequent adjuvant therapy in the field of orthopedics, reducing the probability of misdiagnosis by doctors, saving time and improving efficiency, reducing patient's physical pain and unnecessary economic expenses.

1. Introduction

One of the important aspects of digital orthopedic surgery is the establishment of a digital fracture classification model database (Mardis, 2018). The purpose of fracture classification is to describe the characteristics of fractures (Ponce-Garcia et al., 2017), to make a large number of complicated fracture data organized and systematic, so that it can guide the choice of treatment or intervention treatment methods (Nie et al., 2019), predict the treatment effect, become a tool for education and training (Ge et al., 2018). Correct

classification of fractures is one of the prerequisites for the choice of treatment. The establishment of the fracture classification model database is also one of the foundations for virtual surgery training. The fracture digital model is one of the necessary conditions for virtual surgery of fractures (Stojkovic et al., 2018). Combined with virtual surgical instruments and internal fixation, the corresponding virtual surgery can be completed (Ruikar et al., 2018). At the same time, surgical methods and internal fixations can be selected according to the characteristics of each type of fracture (Poh et al., 2016). Through virtual surgery training, the user can not only increase the proficiency of the operation process, but also gradually understand and master the surgical plan of various types of fractures and the principle of internal fixation selection (Dahake et al., 2016), which can make virtual surgery training more normalized, programmed and standardized (Sun et al., 2018).

Another important goal in the establishment of a three-dimensional model of fracture classification is to establish a three-dimensional or even four-dimensional fracture classification map (Ogawa et al., 2018). The essence of the fracture classification

* Corresponding author.
 E-mail address: zhoufengxin3001@yeah.net (F. Zhou).

system is an "application tool". The fracture map is a manifestation of this tool (Labus et al., 2018). This tool should develop with the development of the times and improve with the advancement of technology, and change with the improvement of requirements, and its external manifestations can and should be changed accordingly (Arent et al., 2017). With the development of imaging technology, the popularity and functional improvement of CT machines (Li et al., 2018). Some scholars carried out CT scan and three-dimensional reconstruction for fracture, especially for complex fracture. It has been found that multiplanar reconstruction can be used to reconstruct coronal, sagittal and arbitrary surfaces, showing the number, course and displacement direction of fracture lines (Gil et al., 2016). At present, there are few researches on the construction of 3D model based on virtual technology in orthopedic surgery, so in this study, this aspect is studied.

In summary, this paper studies the construction of virtual digital 3D models that play an auxiliary role in orthopedic treatment. The results showed that the digital three-dimensional model is very efficient and effective, and plays an important role in the work of orthopedic surgeons and the diagnosis and treatment of patients. The digital three-dimensional model simulated by virtual surgery fully demonstrates its outstanding work ability and greatly eases the burden of doctors. The innovation of the study lies in the comprehensive stimulation test and analysis of the digital 3D model under virtual technology. The research results of the study provided a certain guidance for future research, so this paper is a subject of research value.

2. Methodology

2.1. Digital 3D model establishment

CT data collection: Three fracture patients underwent 16-slice spiral CT (General Electric Company, USA) scan, the first patient was scanned for the pelvis and spine, and the second patient was subjected to CT scan of the lower extremity, the third patients underwent CT scans of the upper extremity. Parameter setting during CT operation: voltage intensity 110–130 kV, current 220–280 mA, spiral distance 1.276–1.66 mm, series 542×542, scanning layer thickness 8.0 mm, the required thickness of model reconstruction is 0.71 mm. The scanned image is automatically saved in the folder that comes with the CT, saved in DICOM format, and then recorded and saved on the CD. Patients and their families have known the specific situation of this study, patients and their families have signed informed consent, and this study has been approved by the hospital ethics committee.

Data input: This study used the professional 3D medical image processing software Mimics 10.01 to digitally model the obtained big data using software. Since the human body has a lot of bones, this study mainly used fracture of acetabulum as a case to show how to establish models and conduct virtual simulations. In the first step, the saved DICOM format image was opened with the auxiliary support of the browser, and the obtained CT image was analyzed, and then the number of layers required for modeling was analyzed to determine the starting and completing layers. The next step is to transfer the saved image to the Mimics 10.01 software, then judge and select the number of layers needed to start and complete, and convert the data. The position of the image was adjusted according to biological logic, including front, back, left, right, and so on.

Image segmentation: The images transmitted to the software mainly include soft tissue and skeleton, and skin. At this study, the picture of the hip bone was separately sorted out, which laid a foundation for subsequent fracture simulation. Open the "Threshold" item in the "Split" column and select the CT bone

value (the spiral CT range was 210-1008Hu) to create a blue "cover". The values and the actual condition of the bones can be changed by users. There was no modification in this case. Using the "cover editing" option to reset the blue "cover", the case studied in this paper intended to re-establish the left hip bone and effectively fill the blank part of the left hip photo, and the tissue bone associated with the left hip bone was cleaned and cut. Create a blue cover on the left hip using the Local Growth option in the segmentation option.

3D reconstruction: Run the software's built-in "three-dimensional creation" function to perform the three-dimensional operation on the blue cover. Select the "quality" calculation method to obtain the digital three-dimensional bone model of the left hip bone. In the next step, the digital three-dimensional model was processed by the software's built-in "lubrication" function to meet the sensory effect requirements of the digital three-dimensional model. The values of these processing modifications can be modified by users. The research setting in this paper required the value of "iteration ordinal number": 10, "smoothing factor": 0.6

2.2. Virtual technology simulation

Virtual simulation: according to the text requirements and image guidance of the type of acetabular fracture, select the "segmentation" function in the "simulation" option to simulate the various displacements and other conditions in the fracture. According to the characteristics of the fracture, each type of fracture can be rotated and moved, and different bones can be marked with different colors. The type of acetabular fracture can be roughly divided into 5 basic and 5 joint types. The 5 basic types mainly include posterior column fracture, posterior wall fracture, transverse fracture, anterior column fracture, and anterior wall fracture. The 5 joint types mainly include double column fracture, transverse posterior wall fracture, posterior column fracture associated with posterior wall fracture, anterior column fracture associated with posterior wall fracture, and comminuted fracture.

Fracture classification: the posterior wall fracture is the case that the fracture line extends to the back of the weight-bearing area of the acetabulum. The posterior column fracture is the case that the fracture line starting from the ischial bone, with the path to the acetabulum, reaching the nodule, the shape of the fracture line is crowned, and there is also a square fracture line, sciatic fracture is caused by bone displacement. The anterior wall fracture is case that the fracture line is only in front of the acetabulum, the fracture line starts in the pelvis, the joint is routed to reach the other side of the pelvis, and then the quadrilateral is passed to the acetabulum. Fracture of the anterior column: the fracture line starts from the crista iliaca or anterior superior iliac spine, and reaches the rami ossis pubis passing the front of the square. The fracture line passes through the crista iliaca in the high anterior column fracture, and passes through the anterior superior iliac spine in the middle fracture, and the psoas muscles of anterior inferior spine in the lower fracture. The anterior column with the posterior semi-transverse fracture: the anterior fracture is similar with the anterior column fracture, and transverse fracture occurs in the posterior half. Double column fractures: fractures of the anterior and posterior columns, the fracture line is often coronal. The square area, the ischial branch, the rami ossis pubis, and the iliac bone are fractured, and the femoral head is displaced inward.

2.3. Statistics analysis

The obtained measurement values were input into the statistical software SPSS 19.0, and a T test was performed to determine whether there is a significant difference between the simulation

of the model after assembly and the actual situation of the patient. If there is, the assembly needs to be adjusted according to the above table, if there is no significant difference between them, and then continue to test the other aspects.

3. Results

3.1. Accuracy research results of digital 3D model production method

The accuracy analysis of digital 3D model and 2D model production method is shown in Fig. 1. From Fig. 1, it can be observed that the three-dimensional digital model based on virtual technology had a significant improvement over the traditional two-dimensional model in terms of data calculation and working level accuracy. It greatly improved the safety of the three-dimensional model in orthopedic treatment, and reduced the deficiency and risk caused by the model, which is very important for the treatment of patients and the development of orthopedic technology.

3.2. The safety research results of digital 3D model storage method

The safety research of digital 3D model and 2D model storage method is shown in Fig. 2. From Fig. 2, it can be observed that the data storage security of digital 3D model was greatly improved compared with the data storage security of 2D model. In orthopedics and other medical fields, the security of data storage is extremely important. If the data is lost, most of the work will not be carried out, which will cause misdiagnosis and the consequences will be extremely serious. This will put a very heavy burden on patients and doctors. The most important thing is that if some data is lost, it will not be re-acquired, and the damage will be unpredictable. Therefore, the digital three-dimensional model based on virtual technology has greatly solved this problem, which is of great value for the development of orthopedics and medical undertakings.

3.3. Digital model analysis results of three-dimensional fracture of anterior wall fracture

The digital model of the three-dimensional fracture of the acetabular fracture-anterior wall fracture is shown in Fig. 3. From the figure, it can be observed that under the action of the virtual digital three-dimensional model, the three-dimensional image of the bone can be observed, including the anterior view, the lateral
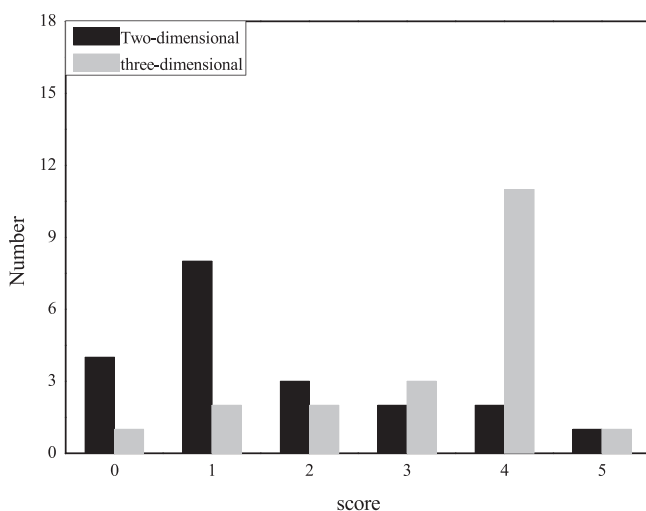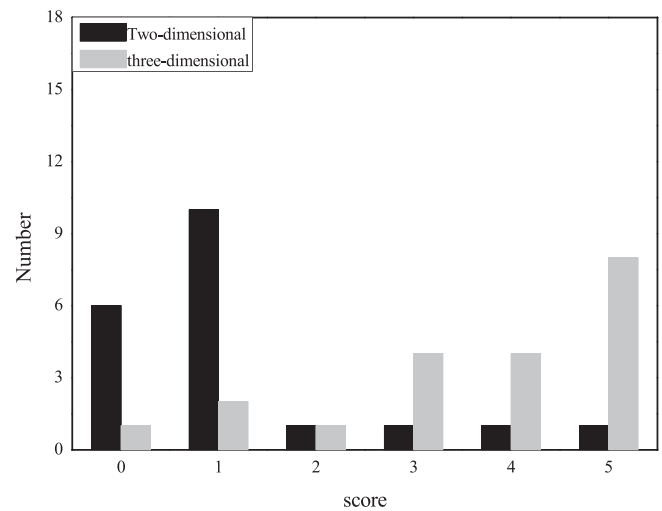

Fig. 2. Comparative analysis of the storage security of 3D model and 2D model.
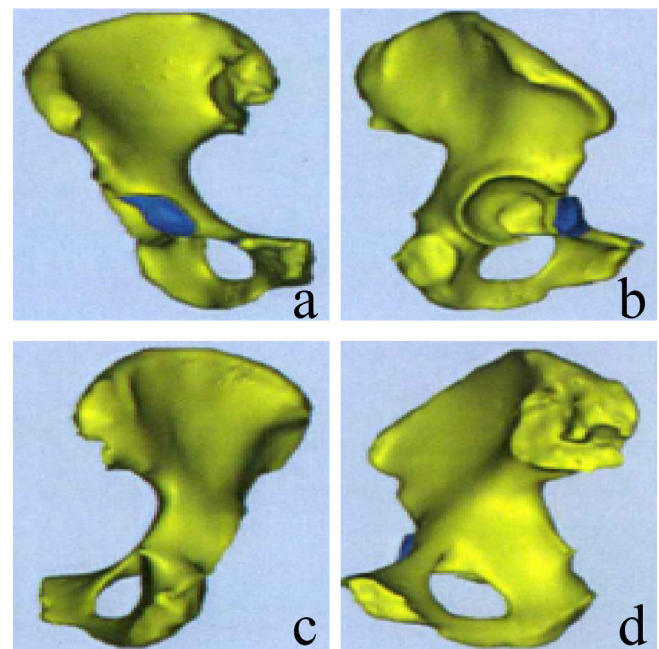

Fig. 3. Digital model of three-dimensional fracture of acetabular fracture-anterior wall fracture (a: anterior view b: lateral view c: posterior view d: medial view).

view, the posterior view, and the medial view. Observation of the three-dimensional bone image has a very important effect on the diagnosis of the patient's condition and the subsequent treatment plan. On the one hand, the patient's body pain and unnecessary economic expenditure are reduced. On the other hand, it greatly eases the workload of doctors and improves work efficiency.

The digital three-dimensional model of orthopedic adjuvant therapy based on virtual technology plays a very important role in the therapeutic application of orthopedics.

3.4. Research results of digital 3D model interacting method

The interaction between digital 3D model and 2D model is shown in Fig. 4. From Fig. 4, it can be observed that the interaction mode of digital 3D model was recognized by most researchers, and the score was relatively high, far exceeding the interaction mode of 2D model. The safety of interaction and the improvement of work
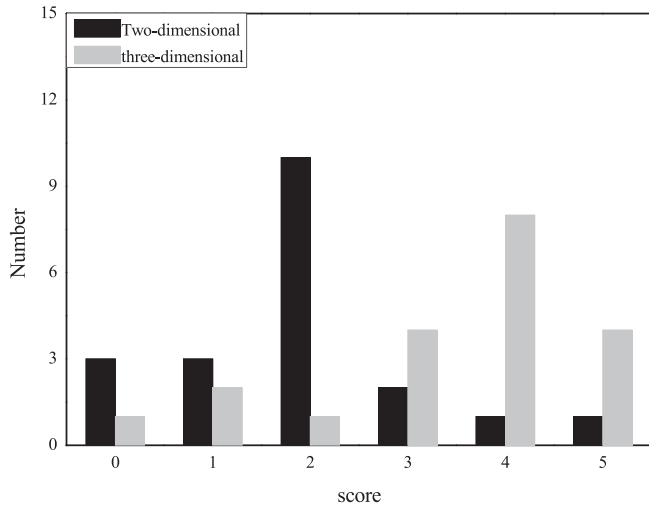

Fig. 1. Comparative analysis of the accuracy of 3D model and 2D model.

Fig. 4. Comparative analysis of the interaction methods of 3D model and 2D model.

efficiency play an important role in improving the efficiency of orthopedic medical work. Because the interaction mode has a very important position in the diagnosis and treatment of orthopedics, the digital three-dimensional model based on virtual technology has greatly improved this problem, which is of great significance for the development of orthopedics.

4. Research results of digital 3D model effectiveness analysis

The effectiveness analysis of digital three-dimensional model of orthopedic adjuvant therapy based on virtual technology is shown in Fig. 5. It can be observed from the figure that the curves of the two-dimensional and three-dimensional digital models were almost the same, and the error is very small, which fully demonstrates the validity of the three-dimensional digital model. It indicates that it can be used in the medical field, and verification of effectiveness is the first and most important step for the digital three-dimensional model. If the effectiveness of the model can't be verified, the model can't be recognized and applied, then there is no subsequent analysis and research. Therefore, the three-dimensional digital model based on virtual technology is in com-
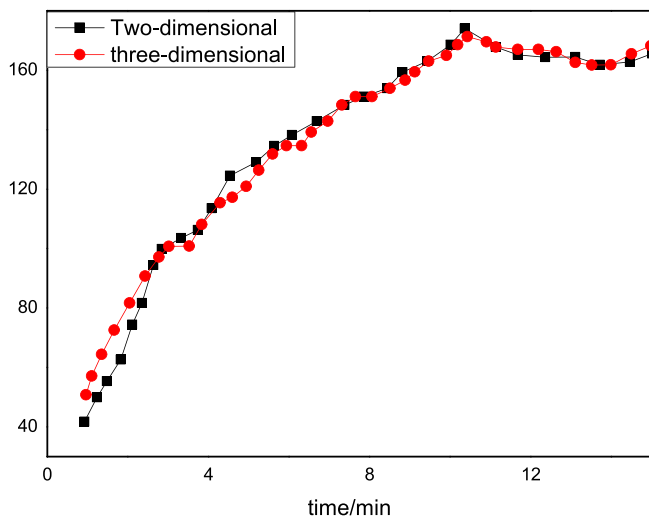
pliance with the requirements and can be used in orthopedic treatment diagnosis and can be popularized.

4.1. Work efficiency study of digital 3D model

The overall working efficiency of digital 3D model and 2D model is shown in Fig. 6. From the figure, it can be clearly observed that the working efficiency of the digital 3D model based on virtual technology was greatly improved compared with the two-dimensional model. No matter in the production method, observation angle, side interaction, color, video mode, etc., each item had obvious improvement, which greatly helps orthopedic treatment, saves time of doctor and improves work efficiency, and reduces the patient's pain and possible misdiagnosis, and allows more patients to receive treatment in time. Therefore, the digital-based 3D simulation model is very prominent for the active treatment of orthopedics, and it is worthy of promotion in other fields to improve the efficiency of other work.

5. Discussion

The objective of this study is to explore the construction of a digital three-dimensional model of virtual technology that plays an auxiliary role in orthopedic treatment. Three fracture patients were selected, with no abnormality was observed in bone examination, no musculoskeletal disease in the past; and spiral CT scan of the spine and pelvis, upper limbs, and lower limbs was performed. The virtual technology was used to build a digital 3D model, mainly using the editing software Mimics10.0 software. In addition, the virtual three-dimensional model was verified by virtual surgery, data storage security, work efficiency of the model, model validity, three-dimensional characteristics of the model, the interaction mode of the model, and the data accuracy of the model were studied. The result showed that the digital 3D model was successfully established by Mimics10.0 software. The data fitting efficiency was very high. The data storage security of the 3D model was greatly improved compared with the 2D model, and the work efficiency was improved by at Many. There was also a significant change in the accuracy and interaction of data acquisition. Therefore, the detection of digital 3D model work through virtual surgery simulation fully demonstrated the positive auxiliary role of 3D model in orthopedic treatment. The three-dimensional model established in this study is basically consistent with the
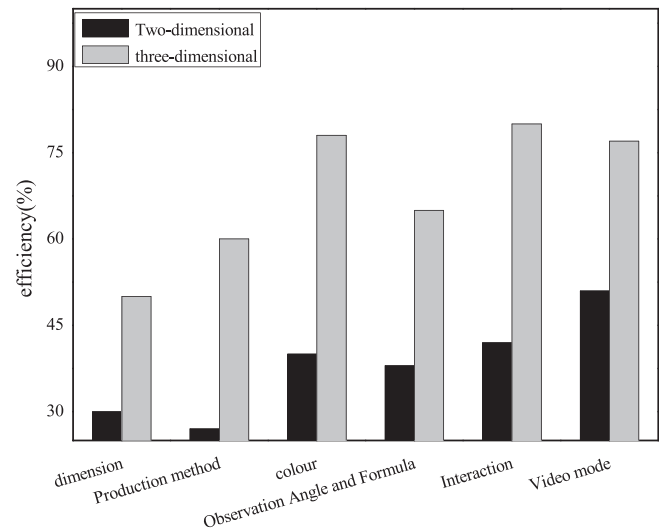

Fig. 5. Effectiveness analysis of digital three-dimensional model of orthopedic adjuvant therapy based on virtual technology.

Fig. 6. Work efficiency study of digital 3D model and 2D model.

actual situation, so the method used in this study has the potential to be applied in the actual situation.

Therefore, this paper studies the effect of digital three-dimensional model on the adjuvant treatment in orthopedics through virtual technology and digital three-dimensional modeling. Digital three-dimensional model can effectively improve the work efficiency in orthopedic adjuvant therapy, solve the risk problem of data security and storage. The research on improving the orthopedic work with the digital 3D model and virtual technology as the core has important research value. The research in this paper is also limited. For example, the process can't be presented in a dynamic form when presenting virtual surgery, but only with static presentation. And the impact of muscle on the results was neglected when building the model, but the research in this paper has important reference value for later researchers.

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