ENHANCING PATIENT AND FAMILY AWARENESS BEFORE SURGERY USING 3D-PRINTED INJURY MODELS IN THE TREATMENT OF COMPLEX PERI-ARTICULAR FRACTURES

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ABSTRACT

Introduction: Peri-articular fractures are common but complex injuries due to the unique anatomical characteristics of joints, such as narrow joint spaces, fragile cancellous bone prone to collapse, and multiple fracture fragments that complicate anatomical reconstruction. Post-treatment sequelae can significantly impact mobility and quality of life. Ensuring that patients and their families understand the extent of injury and the treatment plan is crucial for improving cooperation, reducing anxiety, and minimizing complaints. At Bach Mai Hospital, 3D printing technology—capable of accurately recreating fracture models at a 1:1 scale—was utilized for preoperative patient education, aiming to enhance surgical planning and patient care.

Methods: A prospective study was conducted on 14 patients with complex intra-articular fractures from February to October 2024. All patients underwent CT imaging with 3D reconstruction, followed by the printing of patient-specific fracture models used for preoperative education. Postoperatively, patient satisfaction was surveyed, and clinical and functional outcomes were assessed using joint-specific scoring systems.

Results and Discussion: 64% of patients were of working age, with road traffic and occupational accidents being the leading causes of injury. The 3D-printed models significantly enhanced communication, helping patients and their families better understand the condition and ask relevant questions. Over 90% expressed a desire for continued use of 3D models in future explanations, and 100% reported satisfaction with the treatment process. The mean surgical time was 79.4 ± 26.3 minutes. Only one case (7.2%) experienced a superficial infection, which was managed successfully. More than 90% of patients achieved good or excellent functional outcomes. Viewing and planning surgery with 3D models enabled surgeons to understand anatomy better, reduce operative time, and improve functional recovery.

Conclusions: The use of 3D-printed anatomical models enhances patients' understanding of their injuries and treatment plans, improves satisfaction, and serves as an effective tool to support surgeons in managing complex peri-articular fractures.

Keywords: Peri-articular fracture, 3D-printed models.

1. INTRODUCTION

Peri-articular fractures are common yet complex injuries that frequently result in long-term sequelae due to the anatomical characteristics of joints, such as narrow joint spaces, fragile cancellous bone prone to collapse, and the frequent presence of comminuted fragments that complicate anatomical restoration. One of the critical steps in treatment is the surgeon's responsibility to clearly explain the

extent of the injury, potential surgical challenges, and anticipated postoperative recovery to the patient and their family. This communication not only promotes patient confidence and compliance with the treatment plan but also helps reduce complaints and litigation, thereby improving the overall quality of care [1],[2]

Three-dimensional (3D) printing technology, which enables the reproduction of anatomically accurate models at a 1:1 scale, has seen increasing application in clinical medicine. At the Department of Orthopedic Trauma and Spine Surgery at Bach Mai Hospital, 3D-printed models have been utilized to provide a visual representation of the injury, thereby enhancing preoperative communication between physicians and patients. Building upon this approach, we conducted the study entitled "Enhancing Patient and Family Awareness Before Surgery Using 3D-Printed Injury Models in the Treatment of Complex Peri-articular Fractures" to assess the effectiveness of this tool in improving patient understanding and satisfaction [3],[4]

2. MATERIALS AND METHODS

2.1. Study Population

This study included 14 patients diagnosed with complex Peri-articular fractures who underwent surgery at the Department of Orthopedic Trauma and Spine Surgery, Bach Mai Hospital, between February and October 2024. All patients were provided with 3D-printed models of their injuries before surgery.

- *Inclusion Criteria*

+ Patients aged 18 years or older

+ Diagnosed with complex Peri-articular fractures

+ Indicated for surgical treatment

+ Consent to undergo a 3D CT scan and participate in the study

- *Exclusion Criteria*

+ Patients who declined to participate in the study

2.2. Study Design and Procedure

- Study Design: Prospective observational study

- Sample Size: Convenience sampling

- Study Procedure

+ Conduct clinical assessment and complete medical records for patients with Peri-articular fractures

+ Obtain multidetector CT scans (minimum 32-slice) for high-resolution imaging

+ Generate 3D-printed models replicating fracture morphology

+ Provide preoperative explanations using the 3D models

+ Conduct immediate post-explanation assessments using a pre-established checklist

+ Evaluate patient and family satisfaction

+ Assess postoperative outcomes
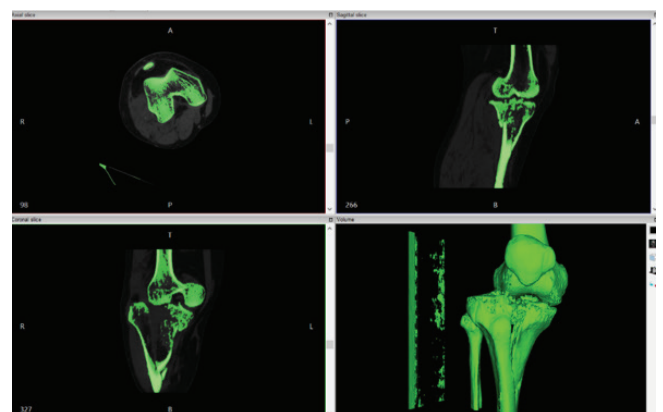
A. Image processing using specialized software was performed to obtain the initial 3D model.
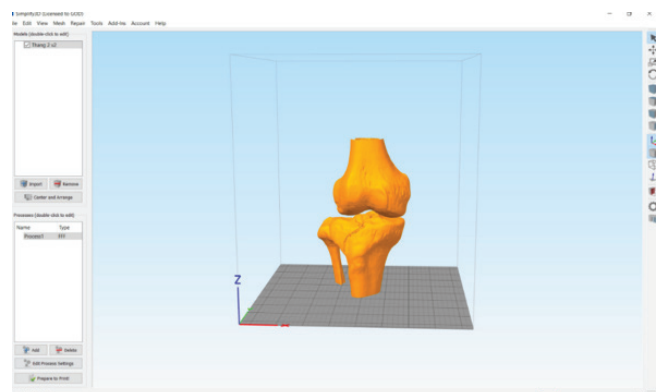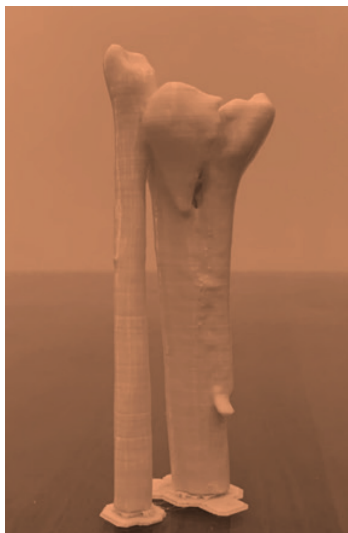

B. Dedicated programming software was then used to prepare the data for 3D printing

Figure 1. Selected steps in the 3D printing workflow.

A. Proximal tibia

B. Ankle joint

C. Distal humerus

Figure 2. 3D-printed models using PLA plastic material applied in the study

- Evaluation Indicators:

+ Survey of patients' and caregivers' expectations regarding disease comprehension.

+ Questionnaire-based assessment of patient and caregiver understanding after receiving 3D model-assisted explanations.

+ Patient satisfaction evaluation at the time of discharge.

+ Assessment of diagnostic and surgical timing, as well as overall clinical outcomes, when the surgeon utilized the 3D-printed fracture model.

2.3. Data Processing Method

All data collected from the evaluation forms were entered and analyzed using SPSS software version 22.2.

3. RESULTS AND DISCUSSION

3.1. General Characteristics of the Study Sample

Table 1. General characteristics of study participants (n = 14)

Characteristic		n (14)	%
Age	< 60 years	9	64.3
	≥ 60 years	5	35.7
Gender	Female	6	43.0
	Male	8	57.0
Residence	Rural	7	50.0
	Urban	7	50.0
Occupation	Intelligentsia	7	50.0
	Farmer	7	50.0

A majority of patients (64.3%) were within working age, consistent with the epidemiological profile of complex periarticular fractures, which are commonly seen in laborers involved in traffic or occupational accidents. These findings are in agreement with previous studies by Yang et al. (2016) [5], Kang et al. (2019)[6], and Nie et al. (2019)[2].

No significant differences were observed in gender, geographic location, or occupational distribution among participants. This could be attributed to the limited sample size and the relatively lower proportion of trauma patients undergoing surgery at the Department of Orthopedic Trauma and Spine Surgery compared to those operated for non-traumatic musculoskeletal conditions.

3.2. Patient Awareness After Explanations Using 3D-Printed Models

Table 2. Patient and Family Awareness Survey

3D Model Features	Patients (n=14)		Family (n=14)	
	Yes (%)	No (%)	Yes (%)	No (%)
Anatomy				
"The 3D model was easy to understand."	10 (71.4%)	4 (28.6%)	9 (64.2%)	5 (35.8%)
"The true-to-size 3D model helped me understand the injured body part."	13 (92.8%)	1 (7.2%)	13 (92.8%)	1 (7.2%)
Communication				
"The 3D model enhanced my communication with the physician."	14 (100%)	0 (0%)	14 (100%)	0 (0%)
"Compared to consultations without a 3D model, having a 3D model improved my awareness."	14 (100%)	0 (0%)	14 (100%)	0 (0%)
Intervention				
"The 3D model helped me understand my diagnosis."	14 (100%)	0 (0%)	14 (100%)	0 (0%)
"The 3D model helped me understand possible complications."	13 (92.8%)	1 (7.2%)	13 (92.8%)	1 (7.2%)
"The 3D model helped me understand treatment options."	12 (85.7%)	2 (14.3%)	12 (85.7%)	2 (14.3%)
"The 3D model helped me understand the treatment plan."	14 (100%)	0 (0%)	13 (92.8%)	1 (7.2%)
Experience				
"The 3D model improved my confidence in making treatment decisions."	14 (100%)	0 (0%)	14 (100%)	0 (0%)
"I would like doctors to continue using 3D models in patient care."	14 (100%)	0 (0%)	14 (100%)	0 (0%)

The use of 3D-printed anatomical models significantly enhanced communication between healthcare professionals and both patients and their families. These models enabled a clearer understanding of the injury, allowing patients to confidently ask questions and overcome feelings of confusion or hesitation when speaking with physicians. Over 90% of both patients and family members expressed a strong desire for continued use of 3D models in future consultations. This high level of acceptance aligns with findings from previous studies, demonstrating that 3D models effectively meet patient needs and expectations during clinical explanation and treatment planning

3.3. Patient and Family Satisfaction Upon Discharge

Table 5. Satisfaction Levels of Patients and Family

	Not Satisfied	Slightly	Moderate	Satisfied	Very Satisfied
Patients	0	0	0	1 (7.2%)	13 (92.8%)
Family	0	0	0	2 (14.2%)	12 (85.8%)

All patients and their families expressed satisfaction with the treatment process, with over 92% of patients and 86% of family members reporting that they were "very satisfied." These findings suggest that clear communication regarding the patient's condition and the planned intervention significantly enhances trust and overall satisfaction. This result is consistent with previous studies by Kang (2019)[6] and Schlegel et al. (2023)[7], reinforcing the importance of effective communication in medical care.

5. CONCLUSION

The use of life-sized 3D-printed models significantly enhances patients' and their families' understanding of the injury, treatment options, and potential intraoperative and postoperative complications. As such, 3D printing not only serves as an effective tool for preoperative communication but also contributes to improving treatment quality and increasing patient satisfaction.

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