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Original Article

Manufacturing and application of personal hand and finger splint with three dimensional printer technology following hand and finger trauma

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Abstract

Aim: To manufacture personal hand and finger splint with three dimensional printer, applying in emergency service patients and comparing with traditional splint applications.

Material and Methods: Personal hand-finger splints were manufactured using three dimensional printer and applied to 25 patients referring to Kutahya Medical Sciences University, Faculty of Medicine, Emergency Medicine Department with upper extremity trauma and requiring hand-finger splints and these were compared with splints in the market which are medical products manufactured with traditional methods for cost, patient comfort and treatment efficiency.

Results: 11 (44%) traffic accidents, 8 work accidents (32%) and 6 (24%) simple home accidents were detected in trauma etiology distribution. Based on the pathologies of the cases, 9 (36%) soft tissue pathologies, 5 (20%) proximal phalangeal, 4 (16%) distal phalangeal, 2 middle phalangeal, 3 (12%) metacarpal bone and 2 (8%) thumb fractures were found. In the controls made for all patients in the third week, it was observed that their complaints were over, they didn't need splints anymore and there was recovery in fusion and soft tissue traumas in control x-rays. In the follow-ups of these cases, it was detected that they easily returned to their daily activities.

Conclusion: In our study, personal hand-finger splints were manufactured and applied to 25 patients using 3 dimensional printer. For all cases, complete recovery was detected in the controls of all cases and fusion was provided based on control x-rays and they easily returned to their daily activities.

Keywords: Finger splint; trauma; 3D printer.

INTRODUCTION

Skeletal system fractures and accompanying soft tissue injuries are the most common injury type for patients. Splint application are very important for the management of simple fractures, dislocations and soft tissue injuries in upper extremities not requiring surgical treatment. (1,2) 3 dimensional print-out is the operation of taking the solid form print of 3 dimensional model which can be found ready anywhere or formed individually. 3D scanning of biological structures made the manufacturing of individualized medical equipment easier (3).

Manufacturing and application of the splints individually for the patient is very important. A splint not manufactured according to the patient and not meeting the patient requirements will cause the treatment to be insufficient (4).

By evaluating the use of hand and finger splints we manufactured for specific patients with 3 dimensional printer, our objective in our study was to compare these splints with medical splints in the market for cost, manufacturing duration and patient comfort.

MATERIAL and METHODS

25 patients referring to Kutahya Health Sciences University, Faculty of Medicine, Energency Medicine Department with upper extremity trauma and requiring hand-finger

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splint were included in the study. Hand-finger splints manufactured in suitable sizes with PLA (Polylactic Acid) before in Kutahya Health Sciences University Innovative Technology Laboratory using 3 dimensional printer were applied in emergency service to patients with splint indication. Splint applied patients were invited for control 3 weeks later, the splints were removed, control x-rays were examined and clinical and life qualities were questioned.

In our project, Ultimaker 2 Extended and Ultimaker 3 Extended 3D printer in Kutahya Health Sciences University Innovative Technology Laboratory and Ultimaker Curas v. 3.4.1 software were used for 3 dimensional printing of splints anatomically exactly suitable for our patient referring to our hospital with splint requirement.

After taking suitable splint measurements of our patients, 3 dimensional models were formed using Solidworks software. After forming STL format for these models, printing was started with Ultimaker 2/3 Extended 3D printer after calculating the temperature, printing speed, support and fullness amount suitable for PLA filament in Ultimaker Cura v. 3.4.1 software.

Patients who have head trauma story, are mentally retarded or under 18 years of age were not included in the study.

RESULTS

14 of the patients were male (56%) and 11 were female (44%) (Figure 1). Average age was detected as 37 (18-71 years). 11 (44%) traffic accidents, 8 work accidents (32%) and 6 (24%) simple home accidents were detected in trauma etiology distribution (Table 1, Figure 2).

Based on the pathologies of the cases, 9 (36%) soft tissue pathologies, 5 (20%) proximal phalanx, 4 (16%) distal phalanx, 2 middle phalanx, 3 (12%) metacarpal bone and 2 (8%) thumb fractures were found (Table 2, Figure 3).

The cost of a splint was calculated as 2 $. In the controls in the third week, it was detected that the complaints of all patients were over, no splints were required and based on control X-rays, fusion and recovery were provided and they also returned easily to their daily life activities.

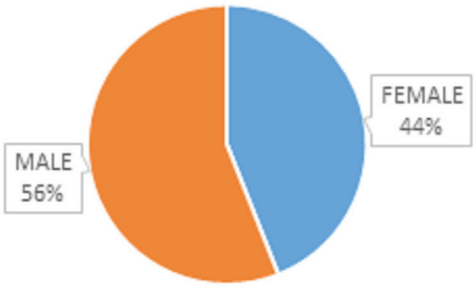

Figure 1. Demographical distribution of the patients

Table 1. Etiological distribution of the patients

Accident Type	Number	Ratio (%)
Traffic Accident	11	44
Work Accident	8	32
Simple Home Accident	6	24

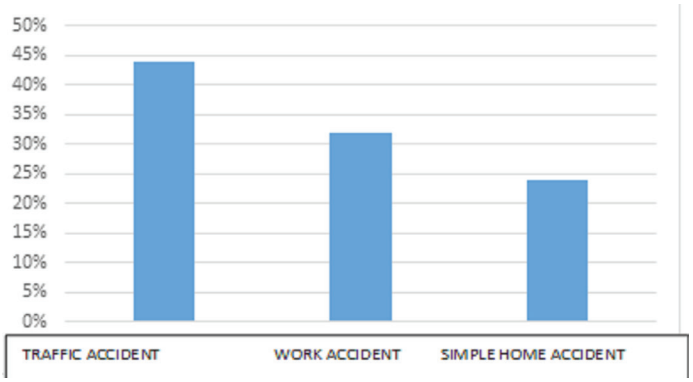

Figure 2. Graphical representation of the etiological distribution of the patients

Table 2. Case pathologies

Pathology	Number	Ratio (%)
Soft Tissue Pathology	9	36
Proximal Phalanx Fracture	5	20
Distal Phalanx Fracture	4	16
Metacarpal Bone Fracture	3	12
Middle Phalanx Fracture	2	8
Thumb Fracture	2	8

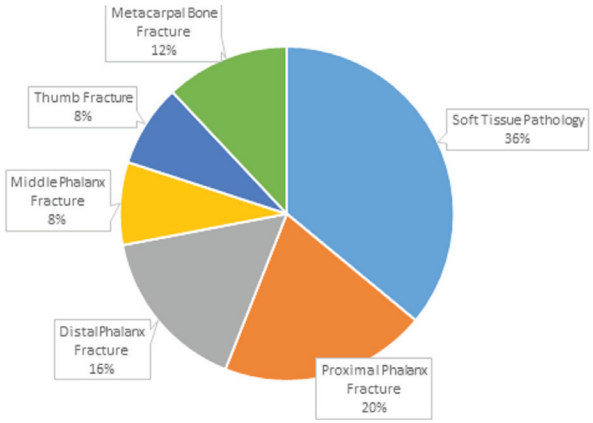

Figure 3. Pathological distribution of patients

DISCUSSION

Functions of hand and fingers are very important in active life. So not being able to move a hand or one of the fingers or having limited movability causes important problems. Hand defects formed by congenital, acquired or idiopathic causes bring along precise treatment approaches. Orthotic approaches are important both before and after conservative or surgical treatment (5,6). With three dimensional printers, biomedical equipment can be formed with desired measurements and materials.

First orthesis manufacturing known in our country was made by Aydın and Kucuk (7). An AFO protype was manufactured with 3 dimensional printer in the study. First of all, it was manufactured through improving 3

dimensional printer open source coded hardware and then it was checked through improving the open source coded software in the study. AFO was manufactured as a prototype. Thus it was not applied on patient.

Although they change according to the manufacturing material and firm, splint prices in our country change between 5 and 10 $. In our study, the cost of a splint manufactured from PLA (Polylactic Acid) raw material with 3 dimensional printer was calculated as 2 $. As orthesis manufacturing with three dimensional printer technology becomes more common, a certain cost and product quality standard can be acquired (8,9). Our study supports this view.

Orthesis manufacturing constitutes a disadvantage of time in patients with acute traumas (8,10). Early intervention on the tissue with pathology is a condition lowering morbidity ratio in patients with trauma. In our study, keeping splints manufactured before in different dimensions ready in emergency service, the ones in suitable dimensions were applied to patients. As three dimensional printer technology and experiences on this technology improve, we think that splint application times would decrease more and thus the morbidity ratio will decrease.

Artefact is an important problem concealing information clinically required in orthopedics practice (11). No artefact was observed in the control x-ray (Figure 4-5) and computed tomography images of the splints we manufactured with PLA material. We think that these splints we manufactured with three dimensional printer may end the illusions which may occur due to artefact in the radiological follow-ups of the patients.

Figure 4. Application of splint produced by 3D printer to patient

Figure 5. X-Ray after use of splint produced with 3D

In the research by Baronio et al, an upper extremity orthesis was made and applied. Scanning was made first between the wrist and fingertip in the study (12). They were manufactured with a 3 dimensional printer when the design and modelling are completed. ABS plastic was used as raw material in manufacturing. In the research made by Wong, finger splint design and application were made for 13 healthy individuals. They were manufactured with a 3 dimensional printer when the design and modelling are completed. ABS plastic was used as raw material in manufacturing (12). All individuals participating in the study reported that 3D printed individual splints safely fitted-in and there was no pain or discomfort (13). On the study they made on a series of patients with hand burns, Nam et al met the orthesis requirements with 3D printed finger splints. It was emphasized that 3D technology could be an alternative for traditional orthesis but more detailed studies are required for this (14). Our study was planned and made for 25 cases and in all cases, complete recovery was detected in the controls and fusion and recovery were provided in control x-rays and they easily returned to their daily activities.

CONCLUSION

Individual orthesis design and manufacturing for the patient with 3 dimensional print technology takes very short time today. As we can see in our study, the manufactured splints are more comfortable, cheaper and aesthetical than splints in the market. We predict that individualized biomedical equipment manufacturing with 3 dimensional print technology will become more common in our country and the world.

Competing interests: The authors declare that they have no competing interest.
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