

ORIGINAL ARTICLE

3D printing utility for surgical treatment of acetabular fractures[☆]



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Received 5 November 2016; accepted 16 February 2018

KEYWORDS

Printing;
Preoperative;
Planning;
Acetabular;
Fractures;
Plates

Abstract

Introduction: Preoperative 3D modelling enables more effective diagnosis and simulates the surgical procedure.

Material and methods: We report twenty cases of acetabular fractures with preoperative planning performed by pre-contouring synthesis plates on a 3D printed mould obtained from a computerised tomography (CT) scan.

The mould impression was made with the DaVinci 1.0 printer model (XYZ Printing). After obtaining the printed hemipelvis, we proceeded to select the implant size (pelvic Matta system, Stryker®) that matched the characteristics of the fracture and the approach to be used.

Results: Printing the moulds took a mean of 385 min (322–539), and 238 g of plastic were used to print the model (180–410). In all cases, anatomic reduction was obtained and intra-operative changes were not required in the initial contouring of the plates. The time needed to perform the full osteosynthesis, once the fracture had been reduced was 16.9 min (10–24). In one case fixed with two plates, a postoperative CT scan showed partial contact of the implant with the surface of the quadrilateral plate. In the remaining cases, the contact was complete.

Conclusions: In conclusion, our results suggest that the use of preoperative planning, by printing 3D mirror imaging models of the opposite hemipelvis and pre-contouring plates over the mould, might effectively achieve a predefined surgical objective and reduce the inherent risks in these difficult procedures.

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[☆] Please cite this article as: Chana Rodríguez F, Pérez Mañanes R, Narbona Cárceles FJ, Gil Martínez P. Utilidad de la impresión 3D para el tratamiento quirúrgico de las fracturas acetabulares. Beca proyecto de investigación SECOT 2014. Rev Esp Cir Ortop Traumatol. 2018;62:231–239.

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PALABRAS CLAVE

Impresión;
Preparatorio;
Planificación;
Acetábulo;
Fracturas;
Placas

Utilidad de la impresión 3D para el tratamiento quirúrgico de las fracturas acetabulares. Beca proyecto de investigación SECOT 2014

Resumen

Introducción: La planificación y premodelado 3D nos permiten un diagnóstico más efectivo y poder realizar una simulación del procedimiento quirúrgico.

Material y métodos: Describimos 20 fracturas de acetábulo en las que se premodelaron las placas de osteosíntesis definitivas sobre modelos obtenidos de estudios de tomografía axial computarizada (TAC) y materializados con una impresora 3D doméstica.

La impresión del molde se realiza con la impresora doméstica DaVinci 1.0 (XYZ Printing®). Tras imprimir la hemipelvis se procede a la selección de los tamaños de los implantes (pelvic Matta system, Stryker®) que más se adapten a las características de la fractura y al abordaje seleccionado.

Resultados: Los minutos medios empleados para la impresión de los moldes fueron 385 (322-539), empleando como media 238 g de plástico (180-410). En todos los casos se obtuvo una reducción anatómica y no fue necesario realizar modificaciones intraoperatorias en la disposición inicial de las placas. El tiempo necesario para realizar la osteosíntesis completa, una vez reducida la fractura, fue de 16.9 minutos (10-24). En un caso fijado con 2 placas, el control radiológico postoperatorio mostró que una de ellas presentó un contacto parcial con la superficie de la lámina cuadrilátera. En el resto el contacto fue total.

Conclusiones: Nuestros resultados sugieren que el uso de la planificación preoperatoria, mediante la impresión 3D de modelos especulares de hemipelvis contralaterales y el premodelado de placas de osteosíntesis sobre ellos, nos lleva a alcanzar eficientemente un objetivo quirúrgico predefinido y a reducir los riesgos inherentes de estos procedimientos complejos.

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Introduction

Acetabular fractures are a surgical challenge for the orthopaedic surgeon. These fractures are generally a result of high energy trauma, with traffic accidents being the main cause, and they are therefore more common for people in their thirties and forties.^{1,2}

The studies presented by Robert Judet and Emile Letournel revolutionised the therapeutic approach and they are still fully applicable nowadays. They considered that the same principles applied in the treatment of joint fractures (anatomical reduction, internal fixation and early mobilisation of the patient) needed to be applied to acetabular fractures.^{3,4}

The anatomy of the pelvis and the acetabulum has been extensively studied, but precise identification of the pattern of fracturing is still complex for orthopaedic surgeons.^{4,5} When pelvic ring fractures need treating the correct surgical approach and obtainment of an anatomical reduction of the bony fragments are key elements, particularly when the acetabulum is involved, because functional prognosis may be compromised.⁶ Absolute congruency between the femoral head and the acetabulum is essential for good long-term outcome. It has been demonstrated that residual displacements over 2 mm lead to early arthrosis of the hip, together with poor functional outcome.³ Given the spatial complexity and anatomical relationships with solid structures, these operations are considered complex and require previous experience which may, on occasions, be difficult to acquire due to a relatively low fracture rate of this type.^{7,8}

With regard to imaging diagnosis, computerised axial tomography (CAT) has been in use since 1982 and has become protocolised testing for these patients.⁴ During recent years, advances in 3D reconstruction of radiologic studies has provided virtual surgical planning tools and these files may even be exported as three-dimensional meshes from which real models can be obtained with 3D printers.

The aim of this study was to study the usefulness of 3D printing for preoperative planning in patients suffering from acetabular fractures who required surgery. We based our study on the use of routine imaging tests carried out on these patients, demonstrating a new methodology for the application of 3D technology through a DIY (do it yourself) process in the field of orthopaedic surgery. Our aim was to see whether we could anticipate intraoperative contouring of the necessary plates to treat these fractures, and also to analyse the advantages and possible drawbacks of this method.

Material and methods

This was an observational, prospective descriptive pilot study with analytical components. It took place from November 2014 to November 2015 when 20 patients were consecutively recruited, who had been admitted to hospital due to acetabular fracture which required surgery.

The study subjects had the following inclusion criteria:

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