"Feasibility study of a new semi-automatic detection method of joint penetration during triple-screw internal fixation for femoral neck fracture"

Englebert, Alexandre ; Cartiaux, Olivier

ABSTRACT

Introduction During a triple-screw internal fixation of femoral neck fracture, joint penetration is difficult to detect without imaging technologies and manual measurements. The screws may appear on the standard antero-posterior and lateral radiographs to be within the femoral head while they are actually penetrating the articular joint [1,2]. The objective of this paper is to study the feasibility of a new semi-automatic detection method of joint penetration during triple-screw internal fixation of femoral neck fractures.

Materials and methods The proposed semi-automatic detection method of joint penetration requires the computation of the tip-to-surface distance (TSD) defined as the distance in mm between the tip of an inserted screw and the articular surface of the femoral joint. A two-step process for the computation of TSD was implemented. First, the tip position of the inserted screw can be manually identified on intraoperative antero-posterior and lateral 2D radiographs. Secon...

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Feasibility study of a new semi-automatic detection method of joint penetration during triple-screw internal fixation for femoral neck fracture

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Context

- Internal fixation of femoral head: Screw positions are difficult to assess on standard 2D radiographs
- Femoral head has a spherical shape: Joint penetration could be unrecognised1,2,3

Background

Femoral head has a spherical shape: Joint penetration could be unrecognised1,2,3

Objective

To propose a new semi-automatic detection method of joint penetration based on standard radiographs

Materials and methods

Our method is based on the Euclidean coordinates of a point in 3D and the computation of the tip-to-surface distance (TSD)1

1. Feasibility study on simulated 3D cases

- Five 3D simulated cases of internal screw fixation of femoral head from CAD software, with theoretical TSD computed for each case.
- Two perpendicular snapshots of each case simulate radiographs

Two operators performed manual identification of the screw tips on simulated radiographs:
- TSDs were computed and compared to theoretical TSDs.
- Correlation coefficient between the two operators was computed

We also used MATLAB® to make an easy-to-use graphic user interface for the method

2. Feasibility study on simulated radiographic cases

Internal fixation on two Sawbones orthopaedic models of femur with non-surgical screws.

MicroScribe® 3D digitizer system:
- 3D geometry

Philips® BV Pulsera mobile fluoroscopy system:
- Radiographs of the femur models.

Radiographs were processed with our software and results compared to references from the 3D digitizer

Results

1. Feasibility study on simulated 3D cases

- Correlation coefficient between the two operators was 0.96
- Maximum difference between reference and semi-automatic method was 1.2 mm
- All penetrated screws were detected
- No unpenetrated screw was considered as a penetrating screw

<table>
<thead>
<tr>
<th>Simulated 3D case</th>
<th>Reference measurements (mm)</th>
<th>Semi-automatic measurements (mm)</th>
<th>Difference (mm)</th>
</tr>
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<td>1.2</td>
</tr>
</tbody>
</table>

2. Feasibility study on simulated radiographic cases

- All penetrated screws were detected
- No unpenetrated screw was considered as a penetrating screw

Discussion

This study showed the feasibility to detect joint penetration during simulated internal screw fixation of femoral neck fracture by using intraoperative 2D radiographs to identify the position of the inserted screw tip and compute the 3D distance relative to the articular surface of the hip joint.

Although these results clearly have to be validated clinically, they may be straightforward to assess the level of accuracy that the detection method needs to be provided with, particularly in terms of the screw tip identification performed intraoperatively by the operator.

References


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