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Technical Report

Economic study: a cost-effectiveness analysis of an intraoperative compared with a preoperative image-guided system in lumbar pedicle screw fixation in patients with degenerative spondylolisthesis

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Abstract

BACKGROUND CONTEXT: In spinal surgery, newly developed technology seems to play a key role, especially with the use of computer-assisted image-guided navigation, giving excellent results. However, these tools are expensive and may not be affordable for many facilities.

PURPOSE: To compare the cost-effectiveness of preoperative versus intraoperative CT (computed tomography) guidance in spinal surgery.

STUDY DESIGN: A retrospective economic study.

METHODS: A cost-effectiveness study was performed analyzing the overall costs of a population of patients operated on for lumbar degenerative spondylolisthesis using an image-guided system (IGS) based on a CT scan. The population was divided into two groups according to the type of CT data set acquisition adopted: Group I (IGS based on a preoperative spiral CT scan), Group II (IGS based on an intraoperative CT scan—O-Arm system). The costs associated with each procedure were assessed through a process analysis, where clinical procedures were broken down into single phases and the related costs from each phase were evaluated. No benefits in any form have been or will be received from commercial parties directly or indirectly related to the subject of this article.

RESULTS: Four hundred ninety-nine patients met the criteria for this study. In total, 2,542 screws were inserted with IGS. Baseline data were similar for the two groups, as were hospitalization and complications. The surgical time was 119±43 minutes in Group I and 92±31 minutes in Group II. The full cost of the two procedures was analyzed: the mean cost, using the O-Arm system (Group II), was found to be €255.83 (3.80%) less than the cost of Group I. Moreover, the O-Arm system was also used in other surgical procedures as an intraoperative control, thus reducing the final costs of radiologic examinations (a reduction of around 550 CT scans/year).

CONCLUSIONS: In conclusion, the authors of the study are of the opinion that the surgical procedure of pedicle screw fixation, using a CT-based computer-guidance system with support of the O-Arm system, allows a shortening of procedure time that might improve the clinical result.

FDA device/drug status: Not approved for this indication.

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However, the present study failed to determine a clear cost-effectiveness with respect to other CT-based IGS.

Keywords: Navigation system; Economic analysis; Costs; Imaging; Spine

Introduction

In recent years, the increasing use of technology has changed many surgical procedures, reducing risks and improving clinical results. Newly developed technologies play a key role in spinal surgery and many results have now been reported in literature. Different tools, such as electrical conductivity measuring devices [1] or different types of computer-assisted image-guided navigation [2–4] have been described and show promising results. In particular, recently introduced systems, such as fluoroscopy-based image guidance (''virtual fluoroscopy'') and computed tomography (CT)-based computer guidance, have considerably reduced the risk of pedicle screw misplacement, showing overall perforation rates ranging from 14.3% to 4.8% [3,5] and represent, in an ever increasing number of departments, the gold standard for instrumented spinal surgery. However, despite these results, a cost-effectiveness analysis is needed. To date, there are no economic studies to show if the acquisition of this technology may or may not be sustainable from the hospitals' point of view besides the useful role it plays in daily practice. The image-guided system (IGS), based on a navigation system and eventually with an intraoperative CT scan, has a high purchasing cost, from €90,000 to €550,000. Although its use may be justified in specialized spinal units, this kind of investment is often not considered an affordable option for many facilities.

Therefore, the purpose of the present study was to validate the methodology of a cost-effectiveness study comparing a computer-guidance system based on a preoperative versus intraoperative CT scan acquisition (O-Arm system, Medtronic, Minneapolis, MN, USA), and to analyze its economic impact on daily practice.

Material and methods

A retrospective cost-effectiveness study [6] was conducted to analyze the overall costs of a population of patients admitted to the Department of Neurosurgery. The patients enrolled in this study had been admitted with a diagnosis of degenerative spondylolisthesis and had undergone a surgical procedure of lumbar pedicle screw fixation using a CT-based computer-guidance system. The navigation system adopted and used in all cases was the StealthStation Treon (Medtronic, Minneapolis, MN, USA). The patients were divided into two groups, according to the type of CT data set used for the navigation system and according to the year of the procedure: Group I (IGS based on a preoperative spiral CT scan, 2008) and Group II (IGS based on an intraoperative CT scan, 2010). All surgical procedures were performed by four neurosurgeons, well experienced in spinal surgery and navigation systems (routinely used in our Department in spine surgery since 2003). The study excluded data concerning the year 2009 in which the O-Arm system was operational, in order to reduce any possible bias because of the learning curve of the new device.

The radiologic protocol for the preoperative (Somatom Volume Zoom, Siemens, Munich, Germany) and intraoperative (O-Arm Imaging system) CT scans was the same as described by the authors in a previous study [5].

The economic evaluation was conducted from a hospital perspective. Costs of the two procedures were measured and valued using an activity-based costing approach [7] (microcosting approach). The procedures were divided into single phases and the costs of each phase were measured and valued. All costs incurred by the hospital, including human resources, operating room (OR) specific machinery (ie, navigation system, O-Arm system, fluoroscopy: considering an 8-year amortization), surgical instruments, consumption materials, drugs, prostheses, and overhead costs, were collected from the hospital's accounting service. The evaluation took into consideration all of the phases, from preadmission testing to discharge of a typical mean pathway of a standard patient who did not present complications. The costs (inclusive of value added tax) data refer to 2010, the material and services consumption levels refer to the clinical practice of years 2008 and 2010, and the cost data were collected from the hospital accounting service referring to 2010 levels.

The effectiveness assessment concerning the two procedures looked at the accuracy of pedicle screw placement. In particular, considered ''effective'' were the screws graded according to the Laine et al. [2] classification as 0, I, and II (maximal cortical violation <4 mm). In fact, screws graded as III or IV are considered potentially dangerous for the nerve root and vascular structures [8], which may lead to secondary interventions. It should be noted that the Lombardy region healthcare service does not reimburse the hospital for a second surgical intervention for the same diagnosis (such as the repositioning of a misplaced screw) within 30 days from the initial intervention.

Statistical analysis was conducted by means of Student *t* test for interval data (economic values, age, time, and number of screws placed) and by means of a chi-square test for nominal data (gender).

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