

Basic Science

Biomechanical comparison of pedicle screw augmented with different volumes of polymethylmethacrylate in osteoporotic and severely osteoporotic cadaveric lumbar vertebrae: an experimental study

Da Liu, MD, PhD^{a,1}, Bo Zhang, PhD^{a,1}, Qing-yun Xie, PhD^{a,1}, Xia Kang, PhD^a, Jiang-jun Zhou, PhD^b, Cai-ru Wang, MD, PhD^a, Wei Lei, MD, PhD^c, Wei Zheng, MD, PhD^{a,*}

^aDepartment of Orthopaedics, Chengdu Military General Hospital, No. 270, Rongdu Ave, Jinniu District, Chengdu, Sichuan Province 610083, China

^bDepartment of Orthopaedics, 184 Hospital of Nanjing Military Region, No. 4, Hudong St, Yingtan, Jiangxi Province 335000, China

^cDepartment of Orthopaedics, Xijing Hospital, Fourth Military Medical University, No. 15, Changle West Rd, Xi'an, Shaanxi Province 710032, China

Received 24 April 2015; revised 14 February 2016; accepted 21 April 2016

Abstract

BACKGROUND CONTEXT: Polymethylmethacrylate (PMMA) is widely used for pedicle screw augmentation in osteoporosis. Intriguingly, there have been no biomechanical comparisons of the stability of pedicle screws augmented with different volumes of PMMA or studies of the relationship between screw stability and volume of PMMA, especially in different degrees of osteoporosis.

PURPOSE: The purposes of the study reported here were to compare screw stability by different volumes of PMMA augmentation, to analyze the relationship between screw stability and PMMA volume, and to make a preliminary determination of the optimum volume of PMMA augmentation for different degrees of osteoporosis.

STUDY DESIGN: This study is a biomechanical comparison of pedicle screws augmented with various volumes of PMMA in cadaveric lumbar vertebrae.

METHODS: Thirty-six pedicles from 18 osteoporotic lumbar vertebrae were randomly divided into groups A0 through A5, and 36 pedicles from 18 severely osteoporotic lumbar vertebrae were randomly divided into groups B0 through B5. A different volume of PMMA was injected into each one of groups A0 through A5 (0, 0.5, 1.0, 1.5, 2.0, and 2.5 mL, respectively) and into each one of groups B0 through B5 (0, 1.0, 1.5, 2.0, 2.5, and 3.0 mL, respectively), and then pedicle screws were inserted in all vertebrae. After complete solidification of the PMMA, we examined pedicle X-rays, performed axial pullout tests, and determined the maximum axial pullout strength (F_{max}) for all samples.

FDA device/drug status: Not applicable.

Author disclosures: **DL, BZ, Q-YX, XK, J-JZ, C-RW, WL, WZ:** Grant: The National Natural Science Foundation of China (81301606) and The Foundation of Chengdu Military General Hospital (2013YG-B015) (A, Paid to the institution), pertaining to submitted manuscript; Consulting Fee or Honorarium: The National Natural Science Foundation of China (81301606) and The Foundation of Chengdu Military General Hospital (2013YG-B015) (A, Paid to the institution), pertaining to the submitted manuscript; Support for Travel to Meetings for the Study or Other Purposes: The National Natural Science Foundation of China (81301606) and The Foundation of Chengdu Military General Hospital (2013YG-B015) (A, Paid to the institution), pertaining to the submitted manuscript; Fees for Participation in Review Activities Such as Data Monitoring Boards, Statistical Analysis, End Point Committees, and the like: The National Natural Science Foundation of China (81301606) and The Foundation of Chengdu Military General Hospital (2013YG-B015) (B, Paid to the institution), pertaining to the submitted manuscript; Payment for Writing or Reviewing the Manuscript: The National Natural Science Foundation of China (81301606) and The Foundation of Chengdu Military General Hospital (2013YG-B015) (B, Paid to the institution), per-

taining to the submitted manuscript; Provision of Writing Assistance, Medicines, Equipment, or Administrative Support: The National Natural Science Foundation of China (81301606) and The Foundation of Chengdu Military General Hospital (2013YG-B015) (B, Paid to the institution), pertaining to the submitted manuscript; Other: The National Natural Science Foundation of China (81301606) and The Foundation of Chengdu Military General Hospital (2013YG-B015) (B, Paid to the institution), pertaining to the submitted manuscript.

The authors have declared that no conflicts of interest exist. Grant support from the National Natural Science Foundation of China (I) and The Foundation of Chengdu Military General Hospital (2013YG-B015, B) was received in support of this work. No benefits in any form have been or will be received from a commercial party directly or indirectly to the subject of this article.

* Corresponding author. Department of Orthopaedics, Chengdu Military General Hospital, No. 270, Rongdu Ave, Jinniu District, Chengdu, Sichuan Province 610083, China. Tel.: +86 28 86571113; fax: +86 28 86571113.

E-mail address: zyzhengwei@126.com (W. Zheng)

¹ These authors contributed equally to this study.

RESULTS: No PMMA was found around the screws in groups A0 and B0. In groups A1 to A5 and B1 to B5, screws were wrapped by gradually increasing amounts of PMMA. There was no PMMA leakage or screw malpositioning in any samples. The F_{max} in groups A1 through A5 increased by 32.40%, 64.42%, 116.02%, 174.07%, and 207.42%, respectively, compared with that in group A0. There were no significant differences in F_{max} between groups A0 and A1, A1 and A2, A2 and A3, A3 and A4, and A4 and A5 ($p > .05$), but there were significant differences in F_{max} between any other two groups ($p < .05$). The F_{max} in groups B1 through B5 increased by 23.48%, 48.40%, 106.60%, 134.73%, and 210.04%, respectively, compared with that in group B0. There were no significant differences in F_{max} between groups B0 and B1, B0 and B2, B1 and B2, B2 and B3, B3 and B4 ($p > .05$), but there were significant differences in F_{max} between any other two groups ($p < .05$). There was a significant positive correlation between F_{max} and volume of PMMA in both osteoporotic and severely osteoporotic lumbar vertebrae ($p < .05$).

CONCLUSIONS: Polymethylmethacrylate can significantly enhance stability of pedicle screws in both osteoporotic and severely osteoporotic lumbar vertebrae. There is a significant positive correlation between screw stability and volume of PMMA. Within a certain range, nevertheless, increasing the volume of PMMA does not significantly improve screw stability. We suggest that 1.5 and 3 mL, respectively, are the volumes of injected PMMA that will optimize pedicle screw stability in osteoporotic and severely osteoporotic lumbar vertebrae. © 2016 Elsevier Inc. All rights reserved.

Keywords: Energy absorbed to failure; Maximum axial pullout strength; Osteoporosis; Pedicle screw; Polymethylmethacrylate; Stiffness

Introduction

Transpedicular screw fixation has been widely used in treating degenerative disorders, unstable fractures, and deformities and tumors of the spine [1–4]. However, osteoporosis severely influences the binding strength of the interface between screws and bone and decreases the holding strength of the screws, which usually results in screw loosening, migration, or back-out [5,6]. Severe osteoporosis increases the need for pedicle screw fixation strength and thus has long been one of the contraindications for spinal internal fixation.

To effectively improve pedicle screw stability in the setting of compromised bone, many researchers have used polymethylmethacrylate (PMMA) to enhance fixation strength [7–21]. There are marked differences for various volumes of injected PMMA and the screw stability that each provides. However, there have been neither any biomechanical comparisons of pedicle screw stability by volume of PMMA nor any studies of the relationship between screw stability and PMMA volume used in different degrees of osteoporosis.

In the study we report here, we injected different volumes of PMMA into both osteoporotic and severely osteoporotic lumbar vertebrae, compared pedicle screw stability by volume of PMMA augmentation, analyzed the relationship between screw stability and volume of PMMA, and conducted a preliminary analysis of the optimal volume of PMMA for both osteoporotic and severely osteoporotic lumbar vertebrae.

Materials and methods

Ethics statement

All procedures involving human cadaveric specimens were conducted according to the ethics guidelines established by our local ethics committee. We obtained approval for our pro-

ocol from the ethics committee of the Fourth Military Medical University and Chengdu Military General Hospital.

Specimen preparation

Anteroposterior and lateral radiographs of each cadaveric spine were obtained to exclude specimens with fractures, deformity, and osteolysis resulting from malignancy. Finally, a total of 36 lumbar vertebrae (L1–L5) were obtained from eight fresh-frozen spines from persons (five women and three men) who died at a mean age of 62 years (range, 51–79 years). The vertebrae were cleaned of all soft tissues, disarticulated at the intervertebral disc space, vacuum sealed in plastic bags, and stored at -20°C for further use. Dual-energy X-ray absorptiometry (Lunar Corp., Madison, WI, USA) measurements, using the definitions of the World Health Organization, confirmed that there were 18 osteoporotic lumbar vertebrae (t score ≤ -2.5) and 18 severely osteoporotic lumbar vertebrae (t score ≤ -3.5). All 72 pedicle screws were identical, with a length of 45.0 mm and an outer diameter of 6.5 mm, and were made of titanium alloy (Medtronic Weigao Orthopaedic Device Co, Ltd, Shandong, China). Polymethylmethacrylate (Cemex, Tecres, Verona, Italy), including cement powder and cement solution, was used for screw augmentation (Fig. 1).

Experimental procedures

All lumbar vertebrae were naturally thawed at room temperature. Thirty-six pedicles from 18 osteoporotic vertebrae were randomly divided into six groups, A0 through A5. Thirty-six pedicles from 18 severely osteoporotic vertebrae were randomly divided into six groups, B0 through B5. In all groups, the screw entry point was at the intersection of the mid-transverse line and lateral to the zygapophyseal joint line, and

Download English Version:

<https://daneshyari.com/en/article/4095733>

Download Persian Version:

<https://daneshyari.com/article/4095733>

[Daneshyari.com](https://daneshyari.com)