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Effective Disc Preparation For Lumbar Interbody Fusion Using SpineJet XL Instruments: Image Analysis of Cadaveric Findings & Comparison to Conventional Tools

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Introduction

The biomechanical and biological advantages of lumbar interbody fusion depend on the ability to prepare the disc space for a solid intradiscal fusion. The minimal required amount of nucleus removal and endplate preparation for successful fusion has not been conclusively elucidated. It has been shown that only 60% of the overall endplate is prepared,[1,3,4] with clearance of only 31% of removable disc material from the contralateral side,[1] using conventional instruments. In the technically challenging transforaminal lumbar interbody fusion (TLIF), recent reports [1,2,3,4,5] suggests that most surgeons probably overestimate the thoroughness of their disc preparation performed using conventional instrumentation. Incomplete removal of disc material can result in a challenging environment for bone fusion[5] and may lead to increased rates of pseudoarthrosis.

The SpineJet XLTM (HydroCision, Inc., Billerica, MA) is the first instrument to combine the power of fluid-jet technology with a unique curette design to meet the specific needs of spinal surgeons. The SpineJet XL may be used in PLIF and TLIF procedures, and may be more effective in disc space preparation than conventional instruments.

Objective

The objective of the study is to compare hydrosurgical versus conventional instruments in disc space preparation through a TLIF approach in a human cadaver model.

Methods

Surgical Technique: Human cadaveric torsos were utilized in this study. The spines were exposed through a standard midline approach by experienced spine surgeons. Access to the disc space wass obtained through an annulotomy via a unilateral transforaminal approach. Removal of disc nucleus and preparation on the endplate for fusion was performed using either conventional instruments, or with hydrosurgical instrumentation from Hydrocision. These hydrosurgical tools are specifically designed to safely and effectively access the entire disc space for nucleus excision and remove cartilage from the endplate. Variously angled instruments (20° and 75°) were utilized.

Study Groups: Nine spine surgeons participated in the study. Only spine surgeons familiar with hydrosurgical instru- ments perfomed discectomy using those instruments. Data was combined from three different cadaveric studies Imaging. After completion of the surgical procedures, each disc level was prepared for image analysis. The spines were disarticulated and the discs were axially sectioned at the level of the endplates and the endplates were digitally photo- graphed. Assessment of the actual and available surface areas of disc removal and endplate preparation in each disc were made using Scion Image image analysis software by an independent blinded spine surgeon. Nine-section grids (3x3) were superimposed on the endplates to allow evaluation of disc space sectors, as described by Javernick,et al.[1]

Analysis: Effectiveness of nucleus removal and endplate preparation using conventional tools was compared to hydosurgical tools evaluating both completeness of disc preparation as well as ability to prepare difficult to access portions of the disc, such as the posterior contralateral area. Additionally, the number of insertions and withdrawals of instruments was documented, and subjective assessment of damage to endplates was performed. A p-value of < 0.05 was considered statistically significant.

Results

Ninety-five percent (95%) of the disc nucleus was removed from the available cross-sectional disc area using SpineJet XL instruments (see Table 1), while effective endplate cartilage removal was achieved in 86% of total available endplate surface area. Instrument insertions withdrawals were more numerous using conventional tools. Subjective evaluation of vertebral endplates demonstrated that TLIF performed

with hydrosurgical instruments resulted in significantly less damage to the bony endplate. In the difficult to access, contralateral posterior disc space, 88% removal of disc from the available cross-sectional disc area was achieved, versus 45% using conventional instruments ($p < 0.00001$). There was no significant difference in the effectiveness of hydrosurgical instruments in removing disc material in this area versus the total disc surface.

Table 1
Key Findings

Parameter	SpineJet XL Devices	Conventional Tools	p-value
Soft tissue removal (% surface area)	95%	81%	<0.001
Endplate preparation (% surface area)	86%	70%	<0.001
Endplate damage (% of endplates damaged)	23%	48%	<0.001
Instrument insertions & withdrawals per level (n)	21	124	<0.001

Discussion

It is widely believed that at least 80% of the disc volume should be removed to produce the optimal environment for lumbar interbody fusion.[4] However, Javernick et al recently demonstrated that conventional instruments in unilateral TLIF removed only 69% of the total disc nucleus removed via a bilateral posterior approach.[1] Postoperative CT images from these same cases revealed that approximately 80% of the cross-sectional area of the endplate had been adequately addressed. The authors concluded that disc removal through a unilateral approach would remove 69% of the available 80% surface area, or only 56% of total possible disc.[1] Similar results have been previously reported (approximately 60% of endplate exposed).[2,3] In this study, 70% removal of disc and cartilage from the available endplate area with conventional instruments is in agreement with these results. Therefore, the effectiveness of disc removal using conventional instruments can be estimated at 56-70% utilizing a unilateral TLIF approach. In marked contrast, hydrosurgical tools permitted removal of 95% of the nucleus and 86% of endplate cartilage from the available endplate surface. Furthermore, effective removal of both disc nucleus and endplate cartilage was achieved even in the difficult to access contralateral posterior quadrant (88%), compared to the 31% previously reported by Javernick, et al.[1]

Safe removal of as much disc material as possible is the goal of disc preparation for lumbar interbody fusion.[5] There are two important considerations in this regard. First, nucleus material in the disc space, especially in the posterior contralateral quadrant, can lead to iatrogenic disc herniation during graft insertion. Second, recent evidence from Bae, et al suggests that the cellular environment in the disc can have a negative inpact on lumbar fusion, even when recombinant bone morphogenetic protein (rhBMP-2) is introduced via a collagen sponge.[6] Their study reported near complete inhibition of fusion with the addition of cells originating from nucleus pulposus, annulus, fibroblast or muscle tissue in a rat model. Despite the improvement in fusion rates with the addition of interbody fusion, the incidence of pseudoarthrosis continues to be significant. A recent radiographic review of 100 consecutive patients undergoing transforaminal interbody fusion revealed solid interbody fusion in only 88% of levels treated (140 levels total).[7]

Based on the current findings in our cadaver model, future research will be aimed at determining the effect of improved disc preparation on fusion and the clinical results associated with this technology. Hydrosurgical disc removal and endplate preparation using SpineJet XL compares favorably to results obtained with conventional instruments. Further research is needed to explore the potential benefits of this technique in preparing the disc space for successful interbody fusion.

Figure 1. Endplate Preparation Using SpineJetXL

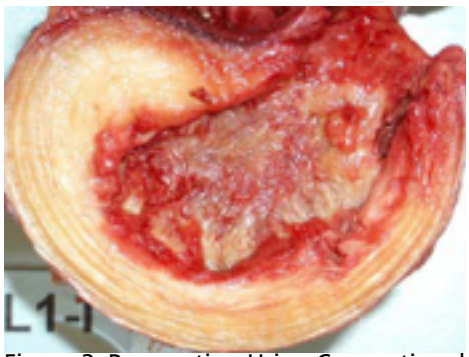

Figure 2. Preparation Using Conventional Instruments (Typical Result; Note Difficult Posterior Contralateral Sector)

References

1. Javernick MA, Kuklo TR, Polly DW Jr. Transforaminal lumbar interbody fusion: unilateral versus bilateral disk removal an in vivo study. Am J Orthop 2003;32(7):344-8; discussion 348.

2. Weistroffer J, Manos R, Sukovich W. Transforaminal lumbar interbody fusion: minimally invasive versus open disc excision and endplate preparation. Paper presented at Society of Military Orthopaedic Surgeons, Vail, Colorado, December 2004.

3. Fox B, Hardenbrook M, Manos R, Sukovich W, Weistroffer JK. Lumbar interbody fusion: the significance of endplate preparation. Poster presented at North American Spine Society, September 27-October 1, 2005, Philadelphia, Pennsylvania.

4. Sukovich W, Hardenbrook M, Taddonio R, Fox B. Hydrosurgical disc preparation for unilateral transforaminal lumbar interbody fusion (TLIF): experimental results in cadavers. Paper to be presented at Society of Military Orthopaedic Surgeons, December 12-16, 2005, Kissimmee, Florida.

5. Sukovich W. Progress, challenges and opportunities in disc space preparation for lumbar interbody fusion. Internet J Spine Surg 2005;1(2).

6. Bae HW et al. Whitecloud clinical award finalist: cellular environments can alter performance of rhBMP-2 and induce pseudoarthrosis. Paper presented at International Meeting on Advanced Spine Techniques (IMAST), July 7-9, 2005, Banff, Alberta, Canada.

7. Potter BK, Freedman BA, Verwiebe EG, Hall JM, Polly DW Jr, Kuklo TR. Transforaminal lumbar interbody fusion: clinical and radiographic results and complications in 100 consecutive patients. J Spinal Disord Tech. 2005;18:337- 346.

Notes

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