ABSTRACT

Objective: This study aims to evaluate changes in lumbosacral parameters after minimally invasive lumbar interbody fusion. The secondary aim was to evaluate whether interbody cage shape (crescent shaped or rectangular) would influence the results. Method: Retrospective analysis of 70 patients who underwent one or two level lumbar interbody fusion through a minimally invasive posterolateral approach. This included midline preservation and unilateral facetectomy. Pre- and postoperative (three to six months postoperative) radiographs were used for measuring lumbar lordosis (LL), segmental lordosis (SL) at the level of interbody fusion, and sacral slope (SS). Further analyses divided the patients into Roussouly lumbar subgroups. Results: LL was significantly reduced after surgery (59°:39°, p=0.001) as well as the SS (33.8°:31.2°, p=0.05). SL did not change significantly (11.4:11.06, p=0.85). There were no significant differences when comparing patients who received crescent shaped cage (n=27) and rectangular cage (n=43). Hypolordotic patients (Roussouly types 1 and 2) had radiographic improvement in comparison to normolordotic and hyperlordotic groups (types 3 and 4). Conclusion: Minimally invasive lumbar interbody fusion caused reduction in lumbosacral parameters. Cage shape had no influence on the results.

Keywords: Lumbosacral region; Spine; Spondylodisc; Spinal fusion; Postural balance; Minimally invasive surgical procedures.

RESUMO

Objetivo: Este estudo visa avaliar modificações dos parâmetros lombossacrais após fusão intersomática lombar minimamente invasiva. O objetivo secundário foi avaliar se o formato do dispositivo intersomático (meia lua ou retangular) influencia os resultados. Método: Análise retrospectiva de 70 pacientes submetidos a fusão intersomática lombar em um ou dois níveis por abordagem posterolateral minimamente invasiva, incluindo preservação da linha média e facetectomia unilateral. Radiografias pré e pós-operatórias (três a seis meses de pós-operatório) foram utilizadas para mensurar lordose lombar (LL), lordose segmentar (LS) no nível da fusão intersomática e inclinação sacral (IS). A avaliação ainda dividiu os pacientes nos subgrupos de Roussouly para lordose lombar. Resultados: A LL diminuiu significativamente após a cirurgia (59°:39°, p=0,001), assim como a IS (33,8°:31,2°, p=0,05). A LS não foi modificada significativamente (11,4:11,06, p=0,85). A comparação dos pacientes que receberam dispositivo em meia lua (n=27) e retangular (n=43) não mostrou diferenças significativas. Os pacientes hipolordóticos (tipos 1 e 2 de Roussouly) apresentaram melhora radiográfica em comparação com os grupos normolordótico e hiperlordótico (tipos 3 e 4). Conclusão: A fusão intersomática lombar minimamente invasiva levou a uma redução dos parâmetros lombossacrais. O formato do dispositivo intersomático não influenciou os resultados.

Descritores: Região lombossacral; Coluna vertebral; Espondilose, Fusão vertebral; Equilíbrio postural; Procedimentos cirúrgicos minimamente invasivos.

RESUMEN

Objetivo: Este estudio visa evaluar modificaciones en los parámetros lumbosacrales después de fusión intersomática lombar mínimamente invasiva. El objetivo secundario era evaluar si los diferentes formatos de los dispositivos intersomáticos (en forma de media luna o rectangular) influirían en los resultados. Método: Análisis retrospectivo de 70 pacientes sometidos a fusión intersomática lombar en un o dos niveles a través de un abordaje posterolateral mínimamente invasivo, incluyendo la preservación de la línea media y facetectomía unilateral. Radiografías pre y postoperatorias (tres a seis meses postoperatorios) fueron utilizadas para medir lordosis lombar (LL), lordosis segmentaria (LS) al nivel de la fusión intersomática y la pendiente del sacro (PS). La evaluación también dividió a los pacientes en subgrupos lumbares de Roussouly. Resultados: La LL disminuyó significativamente después de la cirugía (59°:39°, p=0,001), así como la PS (33,8°:31,2°, p=0,05). La LS no se modificó significativamente (11,4:11,06, p=0,85). No hubo diferencias significativas al comparar los pacientes que recibieron dispositivo en forma de media luna (n=27) y rectangular (n=43). Los pacientes hipolordóticos (tipos 1 y 2 de Roussouly) presentaron mejoría radiológica en comparación con los grupos normolordótico y hiperlordótico (tipos 3 y 4). Conclusión: La fusión intersomática lombar mínimamente invasiva causó una disminución de los parámetros lumbosacrales. El formato de los dispositivos intersomáticos no influyó en los resultados.

Descritores: Región lumbosacra, Columna vertebral, Espondilosis, Fusión vertebral, Balance postural, Procedimientos quirúrgicos mínimamente invasivos.

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INTRODUCTION

Interbody fusion has become a common adjunct to posterior/posterolateral fusion in lumbar degenerative pathology. Its use has long been established in the literature, advocating better fusion rates and improvement in lumbar sagittal alignment when compared to posterolateral fusion alone.\(^1\)\(^2\)

Posterior interbody fusion has the advantages of using the same approach as the one used for decompression and instrumentation, and the natural evolution of the technique has led to the widespread use of transforaminal unilateral interbody fusion, with reduction in surgical time, bleeding, and dural sac retraction.

Currently two different cage designs are commonly used, the bean shaped cage (BSC), which is positioned anteriorly in the intervertebral space, and rectangular/bullet shaped cages (RSC), which are positioned obliquely in the intervertebral space. Proponents of the BSC state its anterior position allows for better lordosis recovery,\(^3\) while proponents of the RSC state that there is no difference in the final results and that there is no need for rotational maneuvers for anterior cage positioning, with little data available to support one shape over the other.\(^4\)

The evolution of minimally invasive techniques has allowed surgeons to perform smaller decompressions for interbody fusion, with reduced muscle retraction, preservation of interspinous ligaments, shorter hospitalization and faster recovery rates. Several studies have compared open to minimally invasive transforaminal lumbar interbody fusion (MITLIF) procedures, showing equivalent results on long term follow up.\(^5\)\(^6\) The fact that more lamina is preserved and that the contralateral facet is preserved might have an implication on its ability to regain lumbar lordosis after MITLIF, in comparison to an open decompression with bilateral facetectomies.\(^7\)\(^8\)

Other factor that has not been taken in consideration on decision making for MITLIF is the type of lumbar lordosis, as different lumbar shapes might need a different surgical strategy.

This study has aims to evaluate the capacity of minimally invasive unilateral TLIF to improve lumbar lordosis, and to determine whether cage shape and preoperative lumbosacral alignment have an influence on the final radiographic outcomes.

MATERIAL AND METHODS

This study is a retrospective analysis from a prospectively collected database of cases from a single center from 2010 until 2012. Informed consent was obtained for all patients as well as ethics committee approval for this study (#089852/2013).

The group consisted of 70 patients (37 male, 33 female, mean age 43 years) who underwent one or two level posterior lumbar fusion with unilateral interbody support using a minimally invasive, muscle-splitting approach. Surgical strategy consisted of midline and paravertebral muscle preservation, and unilateral facetectomy for decompression and cage insertion, followed by bilateral pedicle screw instrumentation.

Diagnosis included degenerative spondylolisthesis (19 cases) and symptomatic disc degeneration with or without lumbar stenosis (51 cases), which would require fusion according to the institution’s protocol.\(^4\)

Patient’s with degenerative scoliosis, previous surgeries at the lumbar spine, symptomatic hip arthritis, lower limb problems that could influence posture and those unable to sign the informed consent for the use of their medical records were not included on this study. Patients with posteriorly placed cages (posterior half of the vertebral body) were also excluded from the study. Regarding disc height, all patients had discs type 3 and 4 (Pfirrmann classification), as type 5 discs do not receive interbody fusion in our institution.\(^4\)

The patients received two different shapes of interbody construct (RSC, 43 patients or BSC, 27 patients), according to surgeon’s preference and experience. Interbody support was used at L4L5 level in 32 cases and at L5S1 in 28 cases, and in 10 cases both levels received interbody support.

Radiographic measurements included segmental lordosis (SL), sacral slope (SS) and lumbar lordosis (LL), pre and postoperatively with a minimum follow up of six months. Images were digitalized and measurements performed using specific software (Surgemap, Nemaris Inc.). SL measurements were meant to evaluate the effect of the cage on local segment lordosis, and calculated using the angle between the endplates adjacent to disc space. LL (measured between the superior endplate of L1 and the superior endplate of S1) and SS (measured between the superior endplate of S1 and horizontal line, parallel to the floor) intended to look at lumbopelvic response to the procedure.

Patient groups were also stratified according to Roussouly’s classification for lumbar lordosis, and statistical comparison between groups used Student’s t-Test for parametric data, where statistical significance would be reached if \(p<0,05\).

RESULTS

Data analysis showed no significant difference between pre and postoperative SL, and the comparison between BSC and RSC has not shown significant differences on the SL, as presented in Table 1. LL and SS were significantly reduced after surgery in both BSC and RSC groups, without significant difference between groups.

Further group stratification regarding age groups and sex showed no significant difference in comparison to the whole group data that could generate a deviation on the statistical analysis. Women had higher radiographic measurements preoperatively, but the changes were similar to males (Table 2) regarding maintenance of SL and reduction on LL and SS.

The patients’ stratification into Roussouly lumbar lordosis types showed a predominance of normolordotic (type 3) patients, over hyperlordotic (types 1 and 2) and hyperlordotic (type 4) as shown in Table 3.

The comparison of radiographic data in these subgroups showed

Table 1. Comparison between pre and postoperative lumbosacral parameters.

<table>
<thead>
<tr>
<th></th>
<th>SL pre</th>
<th>SL post</th>
<th>p</th>
<th>LL pre</th>
<th>LL post</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>All patients</td>
<td>11,4</td>
<td>11,06</td>
<td>0,85</td>
<td>59</td>
<td>39</td>
<td>0,001</td>
</tr>
<tr>
<td>BSC</td>
<td>12,1</td>
<td>10,7</td>
<td>0,2</td>
<td>49,5</td>
<td>41,7</td>
<td>0,01</td>
</tr>
<tr>
<td>RSC</td>
<td>11,3</td>
<td>11,8</td>
<td>0,3</td>
<td>50,4</td>
<td>43,7</td>
<td>0,009</td>
</tr>
<tr>
<td>SS pre</td>
<td>33,8</td>
<td>31,2</td>
<td>0,05</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RSC</td>
<td>33,9</td>
<td>29,8</td>
<td>0,04</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RSC</td>
<td>34,8</td>
<td>32,3</td>
<td>0,1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Comparison between male and female patients.

<table>
<thead>
<tr>
<th></th>
<th>LS pre</th>
<th>LS post</th>
<th>p</th>
<th>LL pre</th>
<th>LL post</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>12,7</td>
<td>12,2</td>
<td>0,4</td>
<td>52,5</td>
<td>43,2</td>
<td>0,003</td>
</tr>
<tr>
<td>Male</td>
<td>11</td>
<td>10</td>
<td>0,4</td>
<td>48,3</td>
<td>42,7</td>
<td>0,02</td>
</tr>
<tr>
<td>SS pré</td>
<td>36,2</td>
<td>33,1</td>
<td>0,08</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SS pós</td>
<td>33,2</td>
<td>29,8</td>
<td>0,05</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3. Stratification according to lordosis type.

<table>
<thead>
<tr>
<th>Lordosis</th>
<th>N</th>
<th>F</th>
<th>M</th>
<th>Mean age</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>12</td>
<td>3</td>
<td>9</td>
<td>45</td>
</tr>
<tr>
<td>2</td>
<td>17</td>
<td>7</td>
<td>10</td>
<td>43,3</td>
</tr>
<tr>
<td>3</td>
<td>35</td>
<td>18</td>
<td>17</td>
<td>43</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
<td>4</td>
<td>2</td>
<td>40,6</td>
</tr>
</tbody>
</table>

N= number of patients; F= female; M= male.

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no significant difference in SL, a significant reduction of LL and SS in the normolordotic group (type 3). The only subgroup that showed some improvement on the postoperative measurements was the type 2, with SS changes approaching statistical significance (p=0.05). (Table 4)

### Table 4. Lumbar values according to lordosis type

<table>
<thead>
<tr>
<th>Lordosis type</th>
<th>SLpre</th>
<th>SLpos</th>
<th>p</th>
<th>LLpre</th>
<th>LLpos</th>
<th>p</th>
<th>S</th>
<th>SSpre</th>
<th>SSSpos</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>11.58</td>
<td>11.16</td>
<td>0.42</td>
<td>44.90</td>
<td>38.85</td>
<td>0.09</td>
<td>29.25</td>
<td>26.58</td>
<td>0.09</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>11.23</td>
<td>11.52</td>
<td>0.44</td>
<td>37</td>
<td>35.75</td>
<td>0.26</td>
<td>24.47</td>
<td>28.52</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>11.94</td>
<td>11</td>
<td>0.29</td>
<td>56.05</td>
<td>44.96</td>
<td>&lt;0.001</td>
<td>39.94</td>
<td>33.48</td>
<td>0.0001</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>11.75</td>
<td>13.66</td>
<td>0.27</td>
<td>64.2</td>
<td>57.16</td>
<td>0.16</td>
<td>42.8</td>
<td>37.16</td>
<td>0.23</td>
<td></td>
</tr>
</tbody>
</table>

SL pre = preoperative segmental lordosis; SL post = postoperative segmental lordosis; p = statistical significance; LL pre = preoperative lumbar lordosis; LL pos = postoperative lumbar lordosis; p = statistical difference.

### DISCUSSION

Interbody cages are an important adjunct to instrumented fusion for decreasing stresses on the posterior implants, allowing for increased fusion rates and allowing for lordosis improvement. Although anteriorly inserted cages allow for better correction due to larger cage shape and improved discectomy, posterior cages have the advantage of being part of a one step procedure, meaning posterior instrumentation and decompression.

The evolution of posterior interbody fusion led to the popularization of unilaterally placed cages (TLIF), which have been adapted for minimally invasive procedures. Such changes have allowed for less aggressive procedures, with preservation of muscular and ligamentous structures.

One of the difficulties of MISTLIF is achieving adequate cage positioning, once most devices (BSC) need to be rotated inside the intervertebral disc space. In this study, the authors have not found a significant advantage of BSC over RSC, despite using all available maneuvers to increase lordosis (specially during patient positioning and compression between pedicle screws), regarding improvement in segmental lordosis or other sagittal radiographic measurements (LL and SS). RSC do not need to be manipulated inside the disc space and this might lead to faster cage insertion, reduced manipulation around the dorsal root and dural sac, and less exposure to radiation. Although some authors have shown advantages of BSC over RSC in open procedures, these results have not been reproduced in MIS case series. (Table 5)

Sakauna et al. have found that the laminar inclination angle has more effect in symptomatic adjacent segment pathology (ASP) after fusion surgery than the actual cage type or position. Other studies clearly show a difference in SL improvement when open and MIS approaches are compared, showing the importance of bilateral facetectomies and perhaps a more aggressive discectomy when aiming for lordosis improvement. (Table 5)

### REFERENCES