ABSTRACT

Objective: To analyze the clinical and radiological evolution, indications and complications of the types of osteotomies in patients with disturbed sagittal balance (SB) resulting from post-traumatic kyphosis. The SB can be measured with a plumb line from the center of the body of C7 to S1, which allows recognizing the misalignment. The imbalance can be corrected by osteotomy. Methods: Thirty patients with SB loss due to post-traumatic kyphosis were studied from January 2014 to December 2017. SPO, PSO and VCR were performed to evaluate the degree of kyphosis before and after surgery; the Oswestry questionnaire was applied and the degree of correction, the days of hospital stay and transfusion bleeding were assessed. Results: Age, 50 years, SD = 14, follow-up time: 2-3 years. We performed 11 (36.7%) osteotomies of S-P, 17 (56.7%) pedicle subtractions and 2 (6.6%) vertebrectomies. Most of the lesions were found between levels L1 and L2; the complications were dehiscence of the surgical wound in 4 patients (13.3%) and infection in 2 (6.6%). The minimum surgical time was 3 hours; the Oswestry questionnaire did not show statistically significant difference during the preoperative period, however, considerable improvement was observed 2 years after surgery. Conclusions: The use of corrective vertebral osteotomies significantly re-establishes the spinopelvic balance altered by different pathologies. It allows correcting in a single surgery the sagittal balance, achieving corrections from 10º to 40º, depending on the type of osteotomy performed, being a safe and effective procedure, which allows to restore the spinopelvic balance, improving the quality of life of the patients. Level of Evidence IIB; Prospective cohort study.

Keywords: Osteotomy; Post-traumatic Kyphosis; Postural balance.

RESUMO

Objetivo: Analisar a evolução clínica, radiológica, indicações e complicações dos tipos de osteotomias em pacientes com desequilíbrio no equilíbrio sagital (ES), por uma cifose pós-traumática. O ES é o fio de prumo que vai do centro do corpo do C7 e permite reconhecer um mau alinhamento. Isso pode ser corrigido por osteotomia. Métodos: 30 pacientes foram estudados com perda no ES por cifose pós-traumática entre Janeiro de 2014 e Dezembro de 2017. SPO, PSO e VCR foram realizados, em que foi avaliado o grau de cifose pré e pós-operatório, o questionário Oswestry foi aplicado para avaliar o grau de correção, dias de internação e sangramento transoperatorio. Resultados: Idade: 50 anos d.s. 14, tempo de seguimento: 2-3 anos. Foram realizados 11 (36,7%) osteotomias de S-P, 17 (56,7%) sustracciones pediculares e 2 (6,6%) vertebrectomías. La mayoría de las lesiones se encontró entre los niveles L1 y L2; las complicaciones fueron dehiscencia de la herida quirúrgica en 4 pacientes (13,3%) y infección en 2 (6,6%). El mínimo time quirúrgico fue de 3 horas; el Cuestionario de Oswestry no presentó diferencia estadísticamente significativa durante el periodo preoperatorio, sin embargo, se observó considerable mejoría 2 años después de la cirugía. Conclusões: El uso de osteotomías correctivas a nivel vertebral reestablece el equilibrio espinopélvico alterado por diferentes patologías. Permite corregir en una sola cirugía el equilibrio sagital, logrando correcciones de 10º a 40º, dependiendo del tipo de osteotomía, siendo un procedimiento seguro e eficaz, que permite restaurar el equilibrio espinopélvico, mejorando la calidad de vida de los pacientes. Nivel de Evidência IIB; Estudo prospectivo de coorte.

Descritores: Osteotomia; Cifose pós-traumática; Equilíbrio postural.

RESUMEN

Objetivo: Analizar la evolución clínica y radiológica, indicaciones y complicaciones de los tipos de osteotomías en pacientes con desequilibrio del balance sagital (BS) resultante de cifosis postraumática. El BS se puede medir con una línea de plomada desde el centro del cuerpo de C7 hasta S1, que permite reconocer la mala alineación. El desequilibrio puede ser corregido mediante osteotomía. Métodos: Se estudiaron 30 pacientes con pérdida del BS por cifosis postraumática en el periodo de enero 2014 a diciembre 2017. Se realizaron SPO, PSO y VCR para evaluar el grado de cifosis pre y postquirúrgica, se aplicó el cuestionario de Oswestry, se valoró el grado de corrección, los días de estancia hospitalaria y el sangrado transoperatorio. Resultados: Edad, 50 años, DE = 14, tiempo de seguimiento, 2-3 años. Se realizaron 11 (36,7%) Osteotomias de Smith-Petersen, 17 (56,7%) sustracciones pediculares y 2 (6,6%) vertebrectomías. La mayoría de las lesiones se encontró entre los niveles L1 y L2; las complicaciones fueron dehiscencia de la herida quirúrgica en 4 pacientes (13,3%) e infección en 2 (6,6%). El tiempo quirúrgico mínimo fue de 3 horas; el Cuestionario de Oswestry no presentó diferencia estadísticamente significativa.
significativa durante el preoperatorio, sin embargo, a los 2 años postoperatorios se observa mejoría considerable. Conclusiones: El uso de osteotomías vertebrales correctoras restablece significativamente el equilibrio espinopélvico alterado por diferentes patologías. Permite corregir en un solo tiempo quirúrgico el balance sagital, logrando correcciones de 10° a 40°, dependiendo del tipo de osteotomía realizada, siendo un procedimiento seguro y efectivo, que permite restaurar el equilibrio espinopélvico, mejorando la calidad de vida de los pacientes.

Nivel de evidencia IIb; Estudio de cohorte prospectivo.

Descriptores: Osteotomía; Cifosis postraumática; Balance postural.

INTRODUCTION

Sagittal balance (SB) is defined as the plumb line that runs from the center of the body of C7 and falls plus or minus 2 cm from the anterior part of the sacral promontory and is used to locate the position of the head in relation to the normal center of gravity (Figure 1).1

Identifying this measurement is relevant to the diagnosis and treatment of the various pathologies that affect the spine, given that, by not identifying and not recognizing misalignment of this plane, there is a risk that patients will have deformities that can cause disability or limiting pain that affects quality of life.

Deformity can cause the loss of this balance, which can be classified as Type I, where the loss of balance is segmental and one portion of the spine is in hyperlordosis or kyphosis, but the balance is satisfactory, or Type II, where the loss of balance occurs when the patient cannot compensate. Another important factor is whether the deformity is located in the thoracic or lumbar spine.2,3

SB can be measured radiologically, allowing assessment of spinal balance and permitting the identification of the degrees of correction that are required in the case of spinal deformity. This can help classify the deformity according to the categories of a) totally flexible, b) partially flexible, and c) rigid.4

Post-traumatic kyphosis is defined as that deformity that presents axial pain or neurological deterioration and that keeps patients symptomatic, resulting from misalignment from the sequela of a complication of treatment of spinal fractures, the main causes of which are non-recognized instability at the beginning of the fracture, poor reduction at the beginning of treatment, pseudoarthrosis, and the premature removal of the implants.5,6

There are multiple techniques for the correction of SB, among them the Smith-Petersen (SPO) or Ponte osteotomy, which includes SPOs performed through the ankylosed segments and the Poncet, performed through the non-fused regions.

There are also the pedicle subtraction osteotomy (PSO) and the vertebrectomy (VCR). It is considered that an SPO can correct 10° per segment, a PSO, 35°, and a VCR, 40° or more, each having its own precise indications and respective complications, which together with improvement of alignment, make them useful procedures (Figure 2).5,9

During the planning of an osteotomy, one must consider: 1) the location of the kyphosis, 2) the risk of neurological injury based on the site of the surgery, 3) the number of osteotomies needed to achieve the correction, 4) the ideal location of the osteotomy, 5) the availability of fixation points and the fusion area, 6) any area of laminectomy present, and 7) bone quality.

The pelvic parameters are extremely important in ensuring optimal correction of sagittal balance.9,13

PI is the angle between the line perpendicular to the sacral promontory and the line from the center of the promontory to the femoral head. The PI is determined by the ranges of the other parameters (PI = PT + SS), PT is the angle between a vertical line and a line from the center of the promontory to the femoral head and measures the alignment between the spine and the center of gravity. The greater the PT, the greater the retraction from the center of gravity. Lastly, the SS is the angle between a horizontal line and a line parallel to the sacral promontory; the smaller the SS, the greater the pelvic retroversion.

Pelvic retroversion is the first step in a cascade of sagittal imbalance and a PT < 25° facilitates a good quality of life, as does a relationship in which LL = PI ± 10°.

The objective of this study is to analyze clinical and radiological evolution and the indications and complications of the types of osteotomies in patients which sagittal imbalance caused by post-traumatic kyphosis.

METHODS

We conducted a prospective, observational, longitudinal, open-label, non-randomized study with a follow-up of 2 to 3 years in 30 patients who underwent surgical correction for loss of balance resulting from posttraumatic kyphosis performed by three spine surgeons between January 2014 and December 2017. The study was approved by the Institutional Review Board as protocol number F-2018-1301-69.

The patients were divided into 3 groups – those who were submitted to SPO, PSO, and VCR surgery, respectively. Data was collected from their medical records (the study participants had signed an informed consent form), including demographic data, such as age and sex, and intervention variables such as osteotomy level, etiology of the deformity, type of surgery (number of screws), fusion level, transoperative bleeding volume, degree of fusion, transoperative and postoperative complications, surgical time, and length of hospitalization. A disability assessment was conducted using the Oswestry questionnaire.

Figure 1. Graphical representation of Sagittal Balance (SB).

Figure 2. Type and location of the osteotomies.
The degrees of pre- and postoperative kyphosis were measured through an evaluation of digital radiographs and the DICOM® and Surgimap® systems, assessing the angle of segmental kyphosis at the location where the osteotomy was performed. Using the upper end plate of the vertebra above the osteotomy and the lower end plate of the vertebra below the osteotomy as a reference, sagittal balance was measured in a spinogram in which the plumb line of C7 and the posterior superior edge of the end plate of S1 were defined.

The analysis was performed using descriptive statistics, estimated absolute and relative frequencies, central tendency, and dispersion. The paired t-test and the Wilcoxon signed-rank test, as well as the Pearson Spearman correlation test were performed and p < 0.05 was accepted as statistically significant, using Epi-Info and Excel programs.

RESULTS

We reviewed the medical records of 30 patients, 16 males (53.4%) and 14 females (46.6%), operated for sagittal balance resulting from post-traumatic kyphosis during the period from January 2014 to December 2017. The average patient age was 50 years (SD 14), with a follow-up of between 2 and 3 years (Table 1).

Eleven (36.7%) underwent SP osteotomies, 17 (56.7%) were submitted to pedicle subtraction, and 2 (6.6%) underwent vertebrectomies. Most of the injuries (19, 63.3%) were located between levels L1 and L2 (Table 2).

The average hospital stay was 4 ± 2 days, the average transoperative bleeding was 1350 ml, and an average of 8 ± 2 transpedicle screws were used per surgery, presenting an average correction of 32º ± 5º with optimal correction of sagittal balance in 23 (73.8%) patients.

Most of the osteotomies performed were at the lumbar level, specifically 8 (26.6%) at L1 and 11 (36.7%) at L2.

As regards the degree of fusion, an optimal level of fusion (remodeling and formation of trabeculae) was observed in all the patients, although it should be noted that the patients submitted to vertebrectomy had a lower average level of fusion than those who underwent SPO and PSO.

The radiological measurements highlighted a kyphosis correction angle of 17º for SPO, 33º for PSO, and 39º for VCR. Among the 3 groups, the modification to the SVA was less in the patients with SPO (2.88 cm) (Table 2).

Complications like dehiscence of the surgical wound and infection requiring the use of VAC were observed in 4 (13.3%) and 2 (6.6%) patients, respectively.

Minimum surgical time was 3 hours and 30 minutes and maximum surgical time was 6 hours, with an average of 4 hours and 20 minutes (Table 3).

There was no statistically significant difference in the preoperative and 2-year follow-up Oswestry disability questionnaire scores among the three groups. However, the changes produced during the two years of evolution following surgery, in which there is a statistically significant difference in the scores of the different items, reflect considerable improvement, decreasing from an initial index of 73% to 31% at two years following pedicle subtraction surgery (Figure 3).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Result</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>30</td>
<td>%</td>
</tr>
<tr>
<td>Age</td>
<td>50</td>
<td>s.d. 14</td>
</tr>
<tr>
<td>Male</td>
<td>14</td>
<td>46.6</td>
</tr>
<tr>
<td>Female</td>
<td>16</td>
<td>53.4</td>
</tr>
<tr>
<td>Osteotomy</td>
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<td>36.7</td>
</tr>
<tr>
<td>Subtraction</td>
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<td>56.7</td>
</tr>
<tr>
<td>Vertebrectomy</td>
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</tr>
<tr>
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</tr>
<tr>
<td>Level T10</td>
<td>1</td>
<td>3.4</td>
</tr>
<tr>
<td>Level T11</td>
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<td>6.6</td>
</tr>
<tr>
<td>Level T12</td>
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<td>13.3</td>
</tr>
<tr>
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<td>26.6</td>
</tr>
<tr>
<td>Level L2</td>
<td>11</td>
<td>36.7</td>
</tr>
<tr>
<td>Level L3</td>
<td>3</td>
<td>10.0</td>
</tr>
</tbody>
</table>

Table 1. Demographic data.

Table 2. Radiological measurements prior to surgery and after 2 years of follow-up.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Preoperative SVA (cm)</th>
<th>Postoperative SVA (cm)</th>
<th>Mean SVA correction (cm)</th>
<th>“p” Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPO (n=11)</td>
<td>3.17 ± 2.1</td>
<td>0.87 ± 0.31</td>
<td>2.30 ± 2.1</td>
<td>2.88 ± 0.05</td>
</tr>
<tr>
<td>PSO (n=17)</td>
<td>12.2 ± 9.1</td>
<td>4.10 ± 3.22</td>
<td>7.46 ± 3.22</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>VCR (n=2)</td>
<td>11.5 ± 9.2</td>
<td>3.23 ± 2.21</td>
<td>7.27 ± 3.02</td>
<td>&gt; 0.05</td>
</tr>
</tbody>
</table>

SVA (sagittal vertical axis); SPO (Smith-Petersen osteotomy); PSO (pedicle subtraction osteotomy); VCR (vertebrectomy).

Table 3. Surgical events.

<table>
<thead>
<tr>
<th>Event</th>
<th>SPO (n=11)</th>
<th>PSO (n=17)</th>
<th>VCR (n=2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood loss</td>
<td>1223 ml</td>
<td>1459 ml</td>
<td>1834 ml</td>
</tr>
<tr>
<td>Surgical time</td>
<td>2 hrs</td>
<td>3.5 hrs</td>
<td>4.5 hrs</td>
</tr>
<tr>
<td>Hospital stay</td>
<td>3 days</td>
<td>3 days</td>
<td>4 days</td>
</tr>
</tbody>
</table>

SPO (Smith-Petersen osteotomy); PSO (pedicle subtraction osteotomy); VCR (vertebrectomy).

Figure 3. Corrective osteotomy. 2 years of evolution.

CONCLUSIONS

Sagittal imbalance is a mechanical problem that causes functional disability and chronic pain, altering the quality of life.

The use of corrective osteotomies at the vertebral level significantly reestablishes spinopelvic balance that has been altered by different pathologies, be they degenerative, infectious, or traumatic.

This type of technique allows correction of sagittal imbalance in a single surgical time, achieving corrections that range from 10º to 40º, depending on the type of osteotomy performed, whether SPO, PSO, or VCR, each of which has its own indications.

Cho, in a study conducted in 2005, compared SPO and PSO osteotomies and observed a correction of 33.0º ± 2º in the SPOs and 31.7º ± 9.0º in the PSOs, with blood loss of 1398 ml ± 738 ml in the SPOs and 2617 ml ± 1645 ml in the PSOs, with 4% postoperative neurological complications.2,5

In his 2001 study, Chen, using transpedicle osteotomies to...
correct thoracolumbar kyphosis, most of them in L2 and L3, achieved an average correction of 34.5° ranging from 15° to 60° without presenting neurological complications. 10

One of the strengths of this study is that it was performed by three spine surgeons, using only a posterior approach and 4-level instrumentation in all cases. It is noteworthy that surgical time has decreased in accordance with the learning curve, currently reaching 3 hours, along with blood loss of 1223 ml to 1834 ml and hospitalization of 96 hours.

A variation in the surgical technique is that, by subtracting the pedicle, a space is created, preserving the cortical layer that, at the moment of compression of the level to be corrected, retracts and generates a protection point towards the root of the level and allows the closure of the osteotomy.

This type of analysis allows the identification of the corrective osteotomy in patients with posttraumatic kyphosis. It is a safe and effective procedure that permits recovery from spinopelvic imbalance, improving the quality of life of the patients.

All authors declare no potential conflict of interest related to this article.

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