Impact of Pregnancy on Loss of Deformity Correction After Pedicle Screw Instrumentation for Adolescent Idiopathic Scoliosis

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Abstract

Study Design: A retrospective multi-center comparative study between patients who had undergone pedicle screw instrumentation for adolescent idiopathic scoliosis (AIS) and had become pregnant vs. had not become pregnant.

Objectives. To evaluate whether pregnancy leads to the loss of deformity correction (LOC) in female patients surgically treated for idiopathic scoliosis. The hypothesis was that pregnancy does not produce loss of correction in women who had undergone spinal fusion for AIS.

Summary of Background Data: There is limited data on the effects of pregnancy on the radiographic outcomes after pedicle screw instrumentation.

Methods. One hundred twenty-eight female patients underwent segmental spinal instrumentation and fusion for AIS between 1999 and 2014 were reviewed. Of them 62 became pregnant (surgery-pregnancy group: SPG) while 66 did not (surgery-non-pregnancy group: SNPG). Radiographic parametres were analyzed before surgery, after surgery, before pregnancy, and up to 1 year after delivery, and at final follow-up (FFU). Health-related quality of life was analyzed using the Scoliosis Research Society outcome questionnaire (SRS-22r).

Results. The mean age at the time of surgery was 16 years in both groups. The mean (SD) preoperative major curves were 65° (12°) vs. 67° (11°), 18° (9°) vs. 17° (9°) immediately after surgery, and 20° (8°) vs. 20° (8°) at the FFU in the SPG and SNPG groups respectively ($p>0.10$ for all comparisons). The mean loss of correction was 3.5° (3°) in the SPG and 4.5 (3) for SNPG groups, respectively. The mean (SD) preoperative thoracic kyphosis (T5-T12) was 26.5° (11.9) for SPG and 24.7° (14.5) for SNPG, after surgery 19.2° (9.5) for SPG, 18.8 (8.9) for SNPG and at the FFU, respectively, 20.3° (9) for SPG and 21.3° (8.5) for SNPG.

Conclusion. Women who have undergone pedicle screw instrumentation and fusion have had one or more pregnancies do not have curve progression or deterioration in the longer-term outcomes as compared to patients who have not become pregnant.

Keywords: Adolescent idiopathic scoliosis, pregnancy, health-related quality of life

Level of Evidence: 3

Introduction

Patients treated for adolescent idiopathic scoliosis (AIS) often voice concerns about the impact of spinal deformity correction surgery on their future quality of life, such as the ability to play sports or perform daily tasks without issue. Since idiopathic scoliosis is 8-10 times more common in women, one of the most often-asked questions from female patients relate to the prospects of getting pregnant, peripartum, labor, and the progression of scoliosis postpartum. Reports are available regarding future quality of life, course of pregnancy, and pain in patients undergoing conservative or operative management for idiopathic scoliosis [1-7]. Back pain and increased risk of nulliparity as well as risk of progression of scoliosis has been reported, but many of these studies include patients operated with Harrington instrumentation, but limited number of studies have reported the effect of pregnancy after segmental pedicle screw instrumentation [20]. There is also limited knowledge on the longer-term outcomes of pregnancy on the health-related quality of life between patients becoming pregnant vs. not.

Loss of deformity correction (LOC) in patients with surgically treated AIS after a long follow-up period has been comprehensively described [8-20]. The aforementioned loss can be related to lack of arthrodesis or pseudarthrosis, inadequate fixation, hardware loosening/fracture, semi-rigid type of implants (hooks, screws, hybrid systems), curvature progression of the uninstrumented segment, a fixation removal secondary to an infection, and the so-called ‘crankshaft’ phenomenon [8,10-18].

The present study aimed to evaluate whether pregnancy leads to LOC in female patients surgically treated for idiopathic scoliosis using segmental pedicle screw instrumentation. We hypothesized that pregnancy does not affect the radiographic or health-related quality of life outcomes in women who had undergone posterior segmental spinal instrumentation.

Materials and Methods

Inclusion and exclusion criteria

Each participating center obtained an approval of ethical committee. A retrospective review of the surgical records was performed to identify female AIS patients who had undergone scoliosis surgery between 1998 and 2014 at various pediatric hospital-based spine centers. All participants provided informed and voluntary consent to participate in the final follow-up (FFU).

The inclusion criteria were the following: age 16–40 years; female patients who underwent spinal correction surgery performed using a modern technique with Cotrel-Dubousset (CD) instrumentation with pedicle screws only via the posterior approach and who did not give birth (surgery-non-pregnancy group, SNPG) or had given birth (SPG (surgery-pregnancy group, SPG). Patients who had subsequent abdominal surgeries, procedures unrelated to AIS, non-operative scoliosis treatment, or other diseases of the spine or abdomen were excluded.

Patient data, risk factors, and quality of life questionnaire

Demographic data were obtained from a review of medical records and radiographic images using standardized data collection forms. Collected data included patient’s age at the time of spinal surgery and at pregnancy, number of pregnancies, course of childbirth and complications, birth weight of the baby, and and mother’s educational level (secondary school qualification/bachelor’s degree/master’s degree) (Table 1). Surgical details collected included number of segments instrumented and fused, type of instrumentation, operative time, blood loss, and complications including re-operations.

All patients filled out SRS-22r questionnaires at final follow-up to evaluate the health-related quality of life.

Radiographic Evaluation

Standing posteroanterior and lateral radiographs were obtained from all patients before surgery, a week after, 1-2 years after surgery, and at the FFU. AIS curves were categorized according to the Lenke classification [4]. The radiographic parameters for evaluating correction rates were Cobb Angle of the major curves,thoracic kyphosis (T5–T12), and apical vertebral translation (AVT). AVT was defined as a distance between the center of the apical vertebra and the C7 plumb line for the thoracic major curve and the center of sacral vertical line (CSVL) for the lumbar major curve on standing radiographs [21-23].

The loss of correction was defined as ≥10° of coronal curve progression in the standing radiographs from immediate postoperative to final follow-up [21]. To minimize the adding-on effect, cases where the major curve progression was measured outside the fused segments were excluded [21,22]. Pseudarthrosis was documented if follow-up radiographs displayed any evidence of loss of fixation (screw pull-out), rod breakage, or a halo effect around screws. Similarly, patients with pseudarthrosis, or those with a loss of fixation were excluded from the reported risk of loss of correction. Skeletal maturity was defined as Risser 5. Patients with

Risser 0-2 were considered to have significant spinal growth left and were compared with Risser 3-5 to study the effect spinal growth. To determine risk factors for correction loss, the relationship between the loss of correction parameters (CA, AVT, thoracic kyphosis) and the following factors were evaluated: skeletal maturity, chronological age at surgery, materials of spinal instrumentations (titanium, cobalt-chrome or stainless), number of fused vertebrae, screw density, preoperative and postoperative values, and the amount of correction obtained by surgery. To evaluate the relationship between skeletal maturity and correction loss, patients were divided into groups of those with Risser 0–2 before surgery and those with Risser 3–5 before surgery (Table 2).

Statistical analysis

Statistica 10.0 software (StatSoft Inc., 2011) was used for all analyses. The compatibility of distribution in quantitative variables with a normal distribution was studied using the Shapiro–Wilk test and non-parametric tests, where appropriate. The Mann–Whitney U test and Kruskal–Wallis were used for between-group comparisons. Correlation analyses were performed using a chi-square test of independence and Spearman's rank correlation coefficient. The sign test was used to compare dependent (paired) samples where the bivariate random variables were mutually independent. Correlations between the rate of correction loss, each Scoliosis Research Society (SRS)-22R domain, and the total score were evaluated using Spearman's rank correlation coefficient. Results were considered statistically significant when the calculated probability (p) was less than 0.05.

Results

Totally, 128 females (mean age at surgery 16 years, range 11 to 25 years) out of 173 eligible participated into this study (i.e., AIS patients who underwent scoliosis surgery between 1998 and 2014 at various pediatric hospital-based spine clinics). There were 42 (32%) patients with Lenke 1 curves, 23 (18%) patients with Lenke 2 curves, 32 (25%) patients with Lenke 3 curves, 11 (8%) patients with Lenke 4 curves, 9 (7 %) patients with Lenke 5 curves and 11 (8%) patients with Lenke 6 curves. The surgical cohort included 66 women with AIS and no pregnancy (SNPG), and 62 with AIS and pregnancy (SPG). The average time from surgery to childbirth was 5 years (range 2–12 years) in the SPG. The average period of gestation was 39 weeks in SPG, and 3% (2/62) of the SPG group had experienced preterm complications. The mean number of fused vertebrae was 9.7 ± 2.4 vertebrae (range, 5-14). The mean screw density was 1.6 in both study groups.

Radiographic Outcomes and Risk of Operation

The mean (SD) preoperative major curves were 65° (12°) vs. 67° (11°), 18° (9°) vs. 17° (9°) immediately after surgery, and 20° (8°) vs. 20° (8°) at the FFU in the SPG and SNPG groups, respectively (p>0.10 for all comparisons). Similarly, the mean correction rates were 78% (range 53–92%) in the SPG and 75% (range 54–91%) in the SNP group. The mean loss of correction was 3.5° (3°) in the SPG and 4.5 (3) for SNPG groups during follow-up (Table 3).

The mean (SD) preoperative thoracic kyphosis (T5-T12) was 26.5° (11.9) for SPG and 24.7° (14.5) for SNP, after surgery 19.2° (9.5) for SPG, 18.8 (8.9) for SNP and at the FFU, respectively, 20.3° (9) for SPG and 21.3° (8.5) for SNP. It was not significantly different from the previous value (p = 0.48).

Risk factors for postoperative loss of correction

There were 35 patients with Risser 0–2 preoperatively and 93 patients with Risser 3–5 (Table 2). There was no differences in the risk of loss correction between these two groups. No significant correlations were found between the chronological age at surgery and the rates of correction loss of the major curve, AVT, or kyphosis (p>0.10 for all comparisons). No significant correlation was recognized between the number of fused vertebrae, fused levels (long fusion vs. short fusion), and loss of correction (p>0.10 for all comparisons). No significant correlation was observed either between the screw density and correction loss. Preoperative and postoperative values, the amount of correction obtained by surgery, larger preoperative kyphosis, were correlated with the increased thoracic kyphosis at two-year follow-up (Table 3).

Quality of life questionnaires

Results for quality of life after surgical treatment showed general satisfaction and were similar for SNPG and SPG (mean values of 3.86 and 3.93, respectively, N.S., Table 4). No significant correlations were observed between the loss of correction and any domains or total scores of the SRS-22R (p>0.10 for all comparisons, data not shown).

Discussion

Studies on scoliosis and its effects on pregnancy and delivery are still scarce. Referring to these studies has proven to be difficult due to the wide variablity of methods applied such as conservation management or operative management employing the no longer used Harrington instrumentation [7, 24-29]. Modern implant systems for spinal deformity correction, comprising of systems with pedicle screws and rods, enable three plane derotation of the spine. Moreover, when combined with osteotomy techniques, they provide between 70 and 90 per cent correction rates (improvement in size of the spinal curvature). Certainly, several factors have a significant role here such as curvature rate, screw density, surgical operation (an osteotomy), skeletal maturity, manual dexterity, surgeon’s knowledge and experience, but also the patient’s healing mechanisms [4, 30-33].

LOC after scoliosis surgery via the posterior approach with spondylodesis has been analyzed in detail and described in the literature [11-14, 16-20]. According to different studies, at the FFU, LOC in the coronal plane was between 2.6° and 31° [11, 13, 15, 16, 19, 20]. Risk factors responsible for the LOC, linked to skeletal maturity, have been identified [16-20].

Analyzing only AIS patients' data, in whom LOC is probably less affected by the 'crankshaft' phenomenon, Hwang *et al.* examined risk factors related to the return of deformity, indicating a relatively high percentage loss of correction (about 8%, Fig. 1) in skeletally mature patients [17]. In the group studied, LOC has been recorded in about 10% of total patients. In this group of patients, the mean LOC was about 10° and was mainly related to the size of the curvature and AVT. Yamada *et al*. [18], on the other hand, suggested that while analyzing loss of correction factors, more attention should be drawn to the right fixation level at planned surgery. The aforementioned conclusion can be substantiated by the fact that 28% of the patients investigated by Yamada *et al.* who lost correction obtained by surgery had extended instrumentation, and the 'crankshaft' phenomenon was observed in only 12% of patients. A more advanced age and skeletal maturity of patients significantly decreases the probability of the 'crankshaft' phenomenon, but a higher percentage of LOC may also have other etiology [17,19].

Limitations

In the current study, the risk of LOC was compared between groups, who had not been pregnant or had been pregnant and given birth after pedicle screw instrumentation for AIS. Exclusion criteria were spinal pain and any radiological symptoms suggesting abnormalities in postoperative spinal fusion. To obtain a more precise and reliable outcome and as it is common in research, attempts were made to exclude patients with pseudarthrosis from the analyses. However, it may be difficult to confirm the diagnosis without computed tomography, which we felt was unethical in the mostly asymptomatic patient group. It is possible that more cases of LOC may be attributed to undiagnosed pseudarthrosis. Manifesting itself as a fixation failure, this pathological condition is usually difficult and time-consuming to diagnose correctly.

Kim *et al.* [36] pointed out that it took on average 32.4 months to diagnose pseudarthrosis radiographically and suggested that some cases might not be visible over the period of up to six years. Thus, in the group of the patients under investigation, a five-year-long follow-up period enhances reliability of this study through enabling selection of the patients without pseudarthrosis. This, in turn, allows for more accurate and thorough assessment of the loss of correction rate. This ability to assess the aforementioned loss more properly is also confirmed by other studies [17,19] wherein pseudarthrosis occurs in as much as 17% of cases with identified loss of correction. Therefore, certainly, undiagnosed pseudarthrosis may contribute to greater LOC. Female patients' radiographs were evaluated pre-operatively, post-operatively as well as within minimum 2-year follow-up and compared against the data concerning giving birth and undergoing surgical treatment for scoliosis.

Comparison with previous studies

According to the studies by Danielsson who performed similar studies on patients who had been surgically treated in accordance to Harrington technique, had been pregnant, and given birth, the mean progression of the Cobb Angle was 3.5° during long-term follow-up and 4% of the patients from this group had progression more than 10° (maximum 14°) [9, 24, 27]. On the other hand, in the group of patients who had been treated conservatively (braces), the mean CA progression after pregnancy was 7.7°, with 31% of the patients showing a higher increase of progression from 11° to 20°. In the group of patients treated conservatively, a correlation was discovered between the main curve progression and number of pregnancies. A 3° correction loss was recorded in this study at FFU, which was statistically insignificant. Both our patients and Danielsson's patients functioned well socially in terms of marital status and number of children, which was similar in patients untreated for scoliosis. No statistically significant difference of LOC in patients who were pregnant and gave birth after surgical correction of spinal deformity has been found in this study. The number of patients with the mean curves of their spine at about 70° and had almost reached skeletal maturity were limited in this study. Operations were performed mostly with the use of relatively large pedicle screws (mainly 6.0 mm in diameter) and 6.35 mm rods (titanium, cobalt-chrome). These spine constructions are stronger than the standard ones. According to studies [16, 17, 19, 36-38], LOC in patients operated on for scoliosis was observed in patients who had their surgery at a stage of skeletal immaturity. In the group studied, LOC was at a level of 5° and thus clinically and statistically insignificant. No other LOC factors related to pregnancy have been determined in this study. We did not measure AVR, because most of our patients did not have preoperative CT. Stainless steel implants and greater numbers of screws are recommended to prevent correction loss, particularly in skeletally immature patients with large and stiff deformities. LOC should be anticipated to the same extent as in patients treated surgically for scoliosis and who never were pregnant [16, 17, 19, 36-38]. Conversely, no obvious correlation was observed between LOC and chronological age at the time of surgery. Although the Risser test and chronological age are most common parameters for predicting the growth of the bones and curve progression in AIS, chronological age may be an inappropriate parameter for predicting LOC. Another reason may be the plasticity of the growing spine, which helps to maintain balance. Although the data necessary to draw conclusions about LOC etiology are inadequate, the results of this study showed a small number of patients with LOC. The number, however, will not be more significant nor will the percent of LOC be greater than in the patients who have undergone surgery for scoliosis but have not been pregnant.

Conclusions

Women who have undergone pedicle screw instrumentation for adolescent idiopathic scoliosis and have had one or more pregnancies do not have curve progression or deterioration in longer-term follow-up compared to surgically patients who have not become pregnant. The loss of correction during pregnancy was lower after pedicle screw instrumentation than previously reported with Harrington or hybrid type of segmental instrumentation. Providers can counsel patients who have undergone surgery for AIS that they are not expected to have detrimental radiographic or clinical effects after pregnancy and child birth.

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