Effect of Long Spinal Fusion Including the Pelvis on Activities of Daily Living Related to Lumbar Spinal Function in Adults with Spinal Deformity

Abstract

Background Spinal sagittal malalignment is managed via long spinal fusion including the pelvis, which reduces the lumbar spinal range of motion, impairing the ability to perform certain activities of daily living. The present study aimed to evaluate the changes in activities of daily living after long spinal fusion in adults with spinal deformity, and to clarify the specific activities of daily living for which patients perceived postoperative improvement or deterioration.

Methods We retrospectively reviewed 40 adults who underwent long spinal fusion in a single institution between 2014 and 2016 (39 females, one male, age 68.5 (52–79) years). Each patient undertook three self-assessed health-related quality of life measures preoperatively and 2 years postoperatively: Oswestry Disability Index (ODI), Scoliosis Research Society (SRS)-22 questionnaire, and Japanese Orthopaedic Association back pain evaluation questionnaire (JOABPEQ). Radiographic outcomes were measured preoperatively and at 2 years postoperatively.

Results The total ODI and all SRS-22 domains were improved at 2 years postoperatively. The JOABPEQ scores were improved at 2 years postoperatively in all domains, except lumbar function. The change in pelvic incidence minus lumbar lordosis correlated with improvements in total ODI, SRS-22 function, and self-image scores. At 2 years postoperatively, satisfaction was correlated with total ODI, all SRS-22 domains, and the pain domain of the JOABPEQ. Subclass analysis of the JOABPEQ lumbar function domain at 2 years postoperatively revealed that 65% of patients had difficulty 'putting on socks or stockings', 42% had great difficulty 'bending forward, kneeling, or stooping', 32% reported improvement in 'sit to stand', and 32% reported deterioration in 'putting on socks or stockings' after surgery compared with before surgery. The JOABPEQ lumbar spine function domain was not correlated with the SRS-22 satisfaction domain.

Conclusions Despite restricting lumbar function, spinopelvic fusion improves health-related quality of life. The JOABPEQ evaluates activities of daily living related to lumbar function.

Introduction

The pathology of adult spinal deformity (ASD) involves not only coronal deformity, but also sagittal malalignment such as loss of lumbar lordosis (LL), retroversion of the pelvis, and anterior shift of the center of gravity axis with stooping. Sagittal malalignment in patients with ASD is associated with physical and emotional disability, and a considerably impaired health-related quality of life (HRQOL) [1, 2, 3]. Sagittal malalignment was quantified by the Scoliosis Research Society (SRS)-Schwab ASD classification system using three radiographic parameters: mismatch between pelvic incidence (PI) and LL (PI-LL), pelvic tilt (PT), and sagittal vertical axis (SVA), with cutoff values reported for each parameter [4]. Improvement of these three parameters is currently the goal of ASD surgery, so corrective long spinal fusion including the pelvis has been widely adopted for these patients, especially those with severe deformities [5, 6]. However, this corrective spinal fusion reduces the range of motion (ROM) of the lumbar spine, causing a decrease in the ability to perform activities of daily living (ADL) related to the lumbar spine [7]. Understanding of these pathological conditions has deepened recently, and tools for the evaluation of lumbar spine function have been developed, typified by the lumbar stiffness disability index (LSDI) [8, 9, 10]. However, no studies have investigated the effect of spinal fusion for restoration of spinal alignment in ASD on ADL related to lumbar function. The present study aimed to compare the pre- and postoperative ADL of ASD surgical patients using self-reported HRQOL questionnaires such as the Oswestry disability index (ODI), SRS-22 questionnaire, and Japanese Orthopaedic Association back pain evaluation questionnaire (JOABPEQ), and to identify the specific ADL for which the patients perceived postoperative improvement or deterioration.

Materials and Methods

Study patients

After receiving institutional review board approval, 149 consecutive patients with ASD were identified in the surgical registry of a single center. The present study is a retrospective case review of these consecutive patients with ASD who underwent corrective spinal surgery in a single institution between 2014 and 2016. The surgical indication for these patients was severe spinal deformity with a stooped posture, abnormal gait, lower back pain due to sagittal imbalance, and lumbar or thoracolumbar kyphosis. To standardize the fusion level of the included patients, we selected patients whose main deformity was localized as a thoracolumbar or lumbar lesion requiring long spinal fusion of more than eight segments from the lower thoracic vertebrae (T9 or T10) to the pelvis. We excluded patients with rigid thoracic deformity requiring upper thoracic fusion, and/or those with posttraumatic severe kyphosis, ankylosing spondylitis, a rounded back due to Parkinson’s disease, or a follow-up duration of less than 2 years. A final total of 40 patients were eligible for study inclusion. The included patients comprised 39 females and one male, with a median age of 68.5 years (range, 52–79 years), and a mean follow-up period for clinical and radiographic outcomes of 33.4 months (range, 24–66 months).

Health-related quality of life domains and the definitions of improvement rate

Each patient undertook three self-assessed HRQOL measures: the ODI [11], SRS-22 questionnaire [12], and JOABPEQ [13] preoperatively and at 2 years postoperatively. We investigated the improvement rate for each subclass in accordance with the definitions reported by Yoshida et al. [14]. For the SRS-22 and JOABPEQ, the improvement rate was calculated as 100 × [2 year postoperative score – preoperative score] / preoperative score. For the ODI, the improvement rate was calculated as 100 [preoperative score – 2 year postoperative score] / preoperative score.

Subclass analysis of the lumbar function domain on the Japanese Orthopaedic Association back pain evaluation questionnaire

To evaluate the impact of limitation of lumbar function, we analyzed each item of the lumbar function domain in the JOABPEQ (Q2-1 to Q2-6), and compared the preoperative and 2-

year-postoperative scores. Each item is described in Figure 1. We defined improvement as an answer of “Yes” preoperatively, and “No” postoperatively for each question from Q2-1 to Q2-5; deterioration was defined as an answer of “No” preoperatively, and “Yes” postoperatively. We defined improvement as an answer more than one level better postoperatively than preoperatively, such as a change from “great difficulty” preoperatively to “no difficulty” or “some difficulty” postoperatively for Q2-6. We defined deterioration as an answer more than one level worse postoperatively than preoperatively, such as a change from “no difficulty” preoperatively to “some difficulty” or “great difficulty” postoperatively for Q2-6.

Radiographic analysis

Anteroposterior and lateral full-length standing spine radiographs were obtained at preoperative and at two years after surgery. Measurements made in the sagittal plane included thoracic kyphosis (T5-T12), LL (L1-S1), SVA, PI, PT, PI-LL and T1-pelvic angle (TPA). These radiographic parameters were classified in accordance with the SRS-Schwab ASD classification [4].

Statistical analysis

Normal distribution of the data was demonstrated with the Shapiro-Wilk test. Changes between the preoperative and 2-year-postoperative radiographic parameters and HRQOL scores were evaluated using the Wilcoxon signed-rank test, and categorical variables were evaluated using Fisher's exact test. The Spearman rank correlation coefficient was used to analyze the correlation between the radiographic parameters and HRQOL. The rates of improvement and deterioration in each question of the JOABPEQ regarding lumbar function were evaluated using the McNemar test. Statistical analyses were performed using the SPSS version 25 statistical software package (IBM-SPSS, Inc., Chicago, IL). A P value of less than 0.05 was considered statistically significant.

Results

Table 1 shows the three sagittal modifiers [4] and radiographic parameters, most of which had improved significantly at 2 years postoperatively.

Improvement rate of the health-related quality of life score

The mean total ODI score and all SRS-22 domain scores were significantly improved at 2 years postoperatively. The mean JOABPEQ scores were improved at 2 years postoperatively in all domains, except the lumbar function domain (Table 2). The mean improvement rate at 2 years postoperatively exceeded 20% in many domains, while the improvement rate did not change at all (-3%) in the lumbar function domain of the JOABPEQ (Table 2).

Correlation between the health-related quality of life scores and radiographic parameters

The correlations between the changes in radiographic parameters and improvement in HRQOL are shown in Table 3. The change in PI-LL correlated with improvement in the total ODI score, and in the function and self image scores of the SRS-22 (Table 3). Table 4 shows the factors affecting patient satisfaction at 2 years postoperatively. The total ODI score and all SRS-22 domains were significantly correlated with satisfaction at 2 years postoperatively. There was no correlation between satisfaction at 2 years postoperatively and any of the JOABPEQ domains, except the pain domain, or the three sagittal modifiers (Table 4).

Subclass analysis of lumbar function in the Japanese Orthopaedic Association back pain evaluation questionnaire

Table 5 shows the subclass analysis of lumbar function in the JOABPEQ (Q2-1 to Q2-6). At 2 years postoperatively, a limitation was perceived by 30% or less of patients in Q2-1, Q2-3 and Q2-4, whereas 65% of patients perceived a limitation in Q2-5 (putting on socks or stockings) (Table 5). Figure 1 shows the rates of improvement and deterioration for each question. Significant improvement was observed in Q2-3, with 32.5% of patients gaining the ability to perform the 'sit to stand' ADL; significant deterioration was observed in Q2-5, with 32.5% of patients losing the ability to perform the ADL of 'putting on socks or stockings' (Figure 1).

Discussion

The current study revealed that the patient-reported lumbar function score in patients with ASD who underwent long spinal fusion including the pelvis had not improved at 2 years postoperatively. Subclass analysis of the JOABPEQ lumbar function domain revealed that 65% of patients had difficulty ‘putting on socks or stockings’, and 42% of patients had great difficulty ‘bending forward, kneeling, or stooping’ at 2 years postoperatively. In addition, 32% of patients perceived a postoperative improvement in the ADL of ‘sit to stand’, whereas 32% of patients perceived a postoperative deterioration in ‘putting on socks or stockings’. The novelty of the present study was the investigation of the improvement and deterioration rates of ADLs related to the lumbar spine by subclass analysis of self-reported lumbar function outcomes. This was not mentioned in previous reports.

Previous studies report that poor sagittal spinopelvic parameters (such as a large SVA or PT) are correlated with poor HRQOL, and surgical correction of spinopelvic parameters results in improvement of HRQOL [1, 2]. An expanded indication of spinopelvic fusion for patients with ASD led to a focus on trunk mobility and ADLs, while the LSDI is used to evaluate lumbar stiffness [9, 10]. Sciubba et al. reported that the scores for most of the LSDI questions did not significantly change from preoperatively to 2 years postoperatively, while there was a tendency for postoperative worsening in Q1 (putting on underwear and pants) and Q4 (personal hygiene functions following toiletting), and a significant postoperative worsening regarding Q2 (socks and shoes) and Q8 (bathing the lower half of the body) [15]. Hart et al. showed that patients who underwent long spinal fusion (more than five segments) had worsened LSDI scores postoperatively, and 35.3% of patients considered lower back stiffness to be a significant limitation on daily activities [16]; however, postoperative lumbar stiffness was reportedly within an acceptable range as a trade-off for improvement in function and pain at 93.8% [16]. Subclass analysis of the lumbar function domain of the JOABPEQ in the current study showed that there was significant deterioration in the ADL of ‘putting on socks or stockings’, while there was no correlation between the lumbar spine function score in the JOABPEQ and the satisfaction score in the SRS-22. Similarly, Hart et al. reported no correlation between final LSDI and satisfaction scores at 2 years postoperatively [17]. These results indicate that the restriction of lumbar function due to spinopelvic fusion does not diminish the benefit of these surgeries.

Bible et al. used a noninvasive electrogoniometer and torsiometer to investigate the relationships between 15 ADLs and lumbar ROM in 60 asymptomatic adults, and reported that a large proportion of lumbar ROM was required for some ADLs such as squatting, bending, sit to stand, stand to sit, putting on socks, and putting on shoes [18]. Hence, patients with long spinal fusion including the pelvis are expected to lose the ability to perform most of these ADLs, and so it is acceptable that 32% of patients postoperatively lost the ability to put on socks or stockings in the present study. However, it was paradoxical that 32% of patients postoperatively gained the ability to perform the ADL 'sit to stand', which requires a large lumbar ROM. The difference between these two ADLs may be the maximum flexion angle required by each activity. Lumbar flexion of up to 30° is required for 'sit to stand', whereas lumbar flexion of up to 50° is required for 'putting on socks' [18]. The ADLs related to the lumbar spine were influenced not only by the lumbar ROM, but also by the ROM of the hip and knee joints. Therefore, support via the ROM of the hip and knee joints and/or the stable spine with postoperative optimal sagittal alignment may have enabled the present patients to postoperatively attain the ability to perform the ADL of 'sit to stand'. In contrast, the loss of the ADL 'putting on socks' was inevitable, even with the support of the hip and knee joints and the postoperatively stable spine, as this ADL requires deeper lumbar flexion.

The SRS-22 is widely used as an evaluation tool for patients with ASD who undergo surgery, but it cannot evaluate lumbar spine function in detail. The ODI is also widely used as an evaluation tool for spinal surgery, and contains some questions to evaluate lumbar spine function, but is not as definitive as the LSDI. Yoshida et al. performed an ODI subclass analysis that revealed that patients with ASD who undergo spinal fusion of more than four levels remain restricted in the two subdomains of 'personal care' and 'lifting', even 1 year postoperatively [14]. In the present study, 60% of patients had difficulty putting on socks or stockings preoperatively, but the remaining 40% of patients did not have difficulty with this ADL. For such patients without preoperative restrictions in putting on socks or stockings, it is necessary to sufficiently explain that the ADLs related to lumbar stiffness become difficult postoperatively.

The current study had some limitations. First, it was a retrospective and single-center study. Therefore, the possibility of unintentional selection bias in the selection of patients could not be fully excluded. Second, we used the JOABPEQ, which is not commonly used as an evaluation tool for ASD worldwide. The present results need to be compared with results obtained using more widespread tools such as the LSDI to determine whether they are universal. Finally, we did not accurately evaluate the postoperative changes in trunk ROM (including the lumbar spine and hip joints), trunk muscular strength, and walking ability. In the future, these parameters should be evaluated, as they may have a greater impact on lumbar spine function than postoperative spinal alignment.

In summary, the HRQOL scores (except the lumbar function of the JOABPEQ) improved along with the correction of global alignment after ASD surgery. Long spinal fusion including the pelvis enabled one-third of patients to gain the ability to perform the ADL of 'sit to stand', and caused one-third of patients to lose the ability to 'put on socks or stockings'. We should recognize these limitations, and thoroughly explain them to patients with ASD and their families.

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Figure Legends

Figure 1. Graph showing the improvement and deterioration rates for each item related to lumbar function in the Japanese Orthopaedic Association back pain evaluation questionnaire. The asterisks indicate significant differences ($P < 0.05$) in McNemar's test.