Ph.D. Dissertation of Medicine

Influence of Hand Grip Strength on Surgical Outcomes After Surgery for Adult Spinal Deformity

성인 척추 변형의 수술적 치료의 결과에 대해 악력이 미치는 영향

August 2021

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Submitting a Ph.D. Dissertation of Medicine

April 2021

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Confirming the Ph.D. Dissertation written by
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July 2021

Chair ____________________

Vice Chair ____________________

Examiner ____________________

Examiner ____________________

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Abstract

Keyword : Hand grip strength; adult spinal deformity; reconstructive spinal surgery; surgical outcomes
Student Number : 2019-34164

Purpose: The purpose of this study was to examine the influence of hand grip (HGS) strength on surgical outcomes after surgery for patients with adult spinal deformity (ASD).
Study Design: A prospective observational study.
Patient Sample: Patients who underwent reconstructive spinal surgery for ASD.
Outcome Measures: Oswestry disability index (ODI), EuroQOL (EQ-5D), and visual analog scale (VAS) for back pain.
Methods: A total of 78 consecutive patients who underwent reconstructive spinal surgery for ASD were included in this study. Patients were assigned to either the high HGS (≥ 26 kg for men and ≥ 18 kg for women, n = 26) or the low HGS group (< 26 kg for men and < 18 kg for women, n = 52) based on their preoperative HGS. The ODI, EQ-5D, and VAS for back pain were assessed preoperatively, and 3 months, 6 months, and 12 months postoperatively and compared between the two groups. The primary outcome measure was ODI scores 12 months after surgery. The secondary outcome measures included the overall ODI scores, EQ-5D, and VAS for back pain, assessed at each time point during the 1-year follow-up period.
Results: As a primary outcome, the ODI score at 12 months after surgery was significantly lower in the high HGS group than the low HGS group ($p < 0.009$). With regards to the secondary outcome measurements, overall ODI score, EQ-5D and VAS for back pain had better outcomes in the high HGS group across each follow-up assessment ($p < 0.001$, $p < 0.001$, and $p < 0.001$, respectively), while they improved significantly with time after surgery in both groups.
Conclusions: Patients with higher preoperative HGS displayed better surgical outcomes, in terms of disability and health-related quality of life at 12 months after reconstructive spinal surgery for ASD. Therefore, the surgical decision for ASD should be made prudently in patients with low HGS.

Table of Contents

Introduction

Study Background

Adult spinal deformity (ASD) is a diverse condition that deeply affects the quality of life of affected individuals by causing a high level of disability and back pain [1]. As a result, there has been a burgeoning research interest in investigating proper treatment of ASD [2–5]. Even though the 'ideal' treatment for ASD is very difficult to define with the currently available research, surgical treatment of ASD appears to be associated with a higher likelihood of clinical improvement compared to conservative treatment [1] (Figure 1). However, considering that ASD is predominantly a problem of the elderly, with a prevalence of up to 68% in individuals aged > 70 years, and that complications of ASD surgery are found in 20% to 40% of cases [6–11], surgical treatment for ASD should be determined carefully [12] (Figure 2,3). Hence, the identification of predictors or prognostic factors for either favorable or unfavorable surgical outcomes should be of paramount importance to select the most appropriate candidates for surgery.

Figure 1. Left: Typical preoperative radiograph of adult spinal deformity patient exhibiting kyphoscoliosis of thoraco−lumbar region. Right: Postoperative radiograph showing successful reconstruction of coronal and sagittal imbalance.

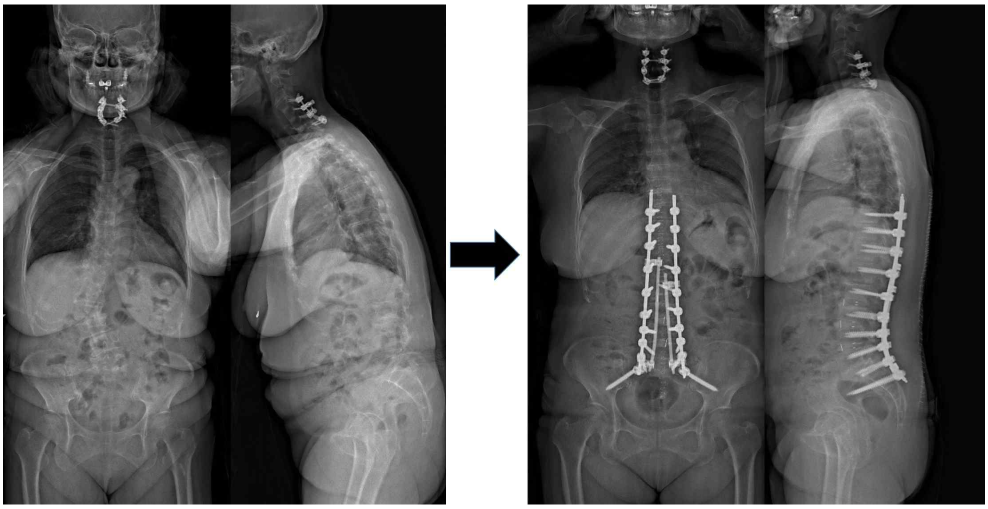


Figure 2. Serial radiographs showing A: Preoperative deformity, B: Successful reconstruction of the deformity, C: Rod breakage (red arrow) with sign of recurrence of coronal imbalance, D: Reoperation with 4−rod system.

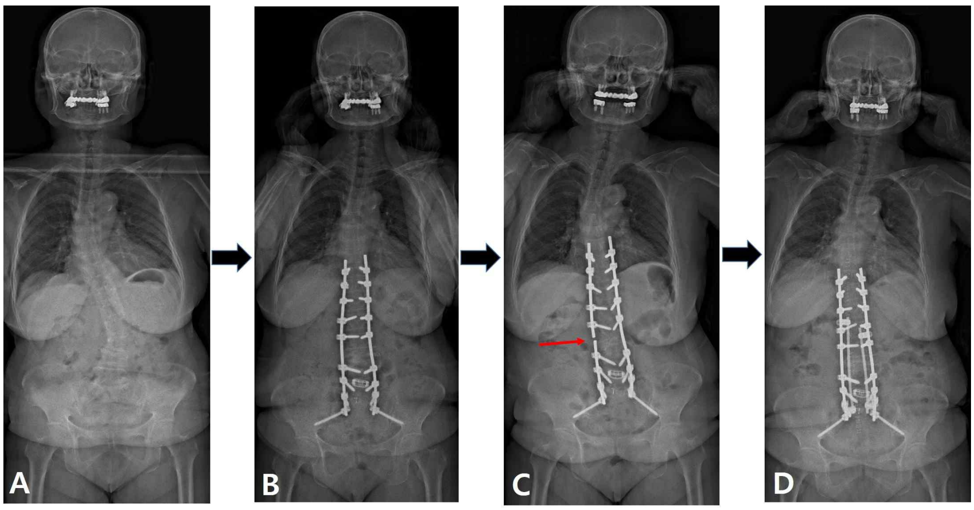
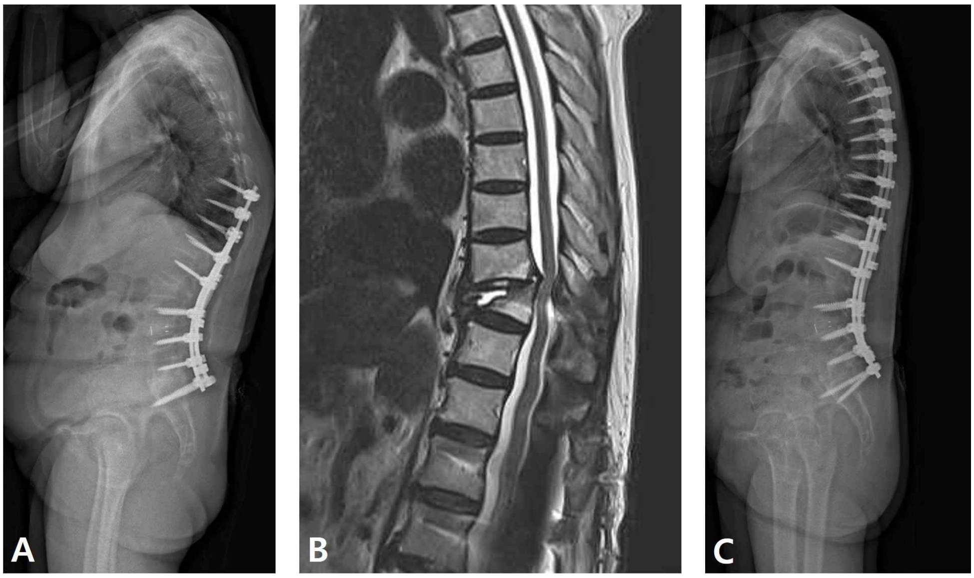


Figure 3. Serial radiographs showing A: Proximal junctional kyphosis with compression fracture of uppermost instrumented vertebra and screw pull-out, B: MRI image showing proximal junctional failure and resultant cord compression, C: Reoperation with decompression and extension of instrumentation up to T4 level.



Purpose of Research

Hand grip strength (HGS), a measure of voluntary muscle function, has often been used as an indicator of muscle strength. An increasing number of studies have demonstrated the high predictive value of HGS for nutritional status and sarcopenia, as well as it being a simple, quick, and low-cost method of measurement [13-15]. Previous studies have also shown a close correlation between surgical outcomes and HGS [14, 16, 17]; however, the prognostic value of HGS for the surgical outcomes of ASD is currently unknown. We hypothesized that HGS would be a prognostic indicator for surgical outcomes after deformity surgery for ASD. Therefore, the purpose of this study was to investigate the influence of HGS on treatment outcomes after surgery for ASD.

Materials and Methods

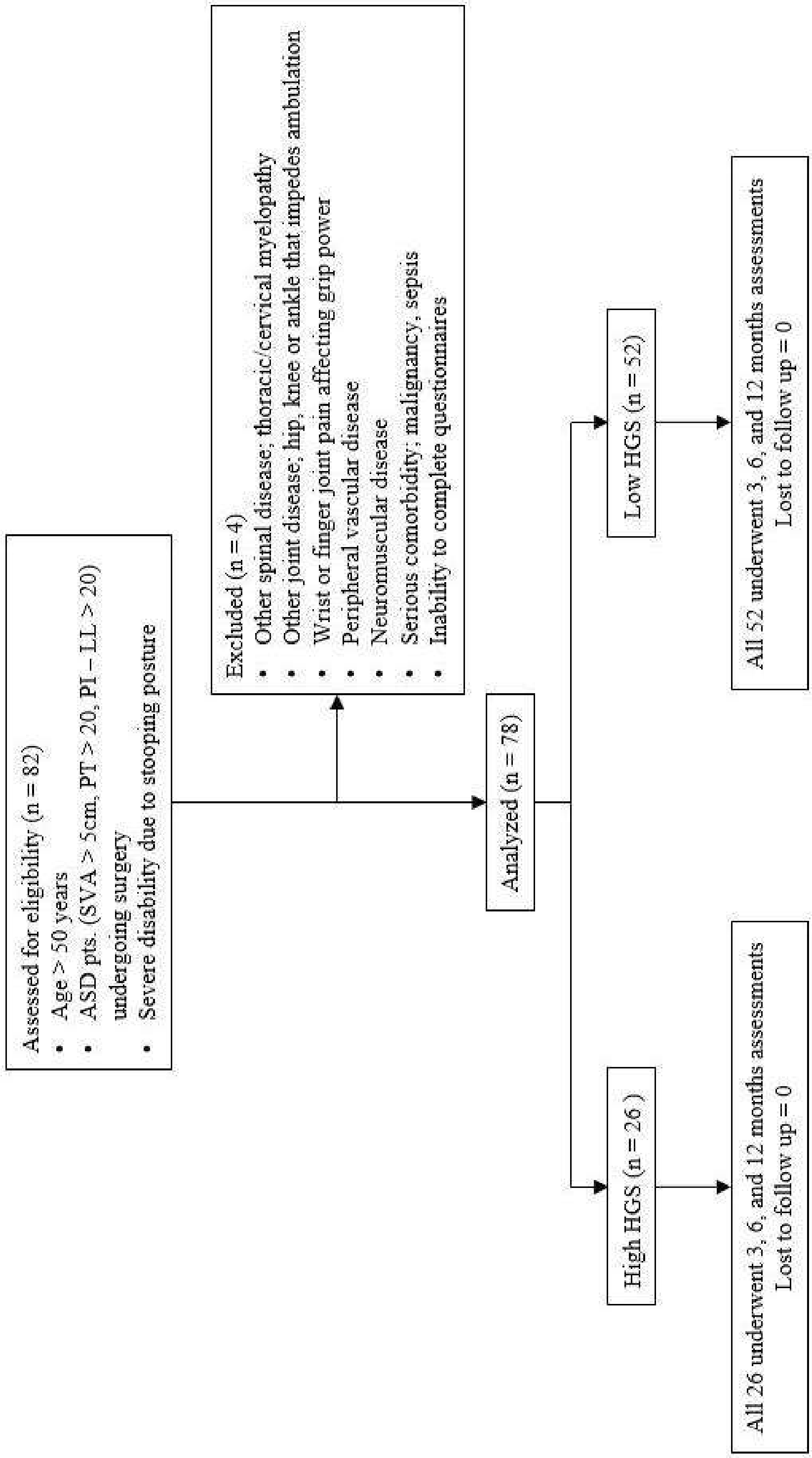
Study design and patients

This was an observational cohort study that was approved by the Institutional Review Board of our hospital. A total of 78 consecutive patients who were scheduled to undergo reconstructive spinal surgery for ASD between September 2016 and December 2018 were included in the study. Power analysis calculation with "large" effect size and allocation ratio of two, considering the frail population, suggested a total sample size of 58. The inclusion criteria for the ASD group were as follows: 1) age above 50 years; 2) diagnosis of ASD with sagittal imbalance and treatment plan of corrective surgery, defined as sagittal vertical axis (SVA) > 5 cm, pelvic tilt (PT) > 20°, or pelvic incidence (PI) – lumbar lordosis (LL) > 20 on lateral radiographs in a standing position; and 3) severe disability due to a stooping posture. The exclusion criteria were as follows: 1) presence of any other spinal disease such as thoracic and/or cervical myelopathy; 2) severe pain in the hip, knee, or ankle joints impeding walking; 3) Wrist or finger joint pain affecting grip power; 4) peripheral vascular disease; 5) any syndromic, neuromuscular disease; 6) any serious uncontrolled medical comorbidity such as sepsis or malignancy that would cause disability or worsen the general medical condition; and 7) inability to complete the questionnaires on health-related quality of life and disability. According to these criteria, of the 82 initially included patients, 78 were finally enrolled in the study.

Measurement of HGS and group allocation

HGS is one of the routine preoperative exams for patients who are scheduled to undergo surgery in our department. The HGS was measured for both hands using a hand dynamometer (GRIP-D5101, Takei, Niigata, Japan). The patients were asked to sit in a comfortable position with their elbows extended to the side and to squeeze the dynamometer with maximum strength. Measurement was performed twice for both hands with a short break in between [15]. The best performance of the trials was recorded and entered into the analysis, regardless of the side and dominance of the hand used. The patients were divided into two groups: high HSG group (≥ 26 kg for men and ≥ 18 kg for women) or low HGS group (< 26 kg for men and < 18 kg for women); these groups were based on the cut−off values suggested in a previous study in which HGS values of < 26 kg for men and < 18 kg for women were used to define sarcopenia according to the guidelines set by the Asian Working Group for Sarcopenia [18] (Figure 4).

Figure 4. Flow diagram of enrollment, allocation, and follow-up of the study participants.



Surgical procedures

All surgeries were performed by the lead author using the same surgical methods. Patients were positioned prone on a Jackson spine table for maximal lumbar lordosis, and simple radiographs were taken. Using the image, the PI – LL was calculated to determine the desired correction angle and thus whether a 3-column osteotomy (pedicle subtraction osteotomy [PSO] or vertebral column resection [VCR]) or posterior column osteotomy (PCO) was necessary for proper correction of sagittal imbalance. In terms of surgical approach, muscle dissection rather than periosteal dissection was performed from the UIV-2 level and above to avoid soft tissue damage and preserve interspinous ligaments and facet capsules. The fusion level was carefully decided by considering both sagittal and coronal plane deformities. Fusion down to the sacrum and S2-iliac screw insertion was performed in most of the patients in order to sustain the long construct and to avoid hastened degeneration of the L5/S1 disc. Surgical techniques such as interbody fusion with a cage and bone graft at lower lumbar levels, cantilevering of rods, and compression between screws were utilized to complement the deformity correction. A thoraco-lumbo-sacral orthosis was applied to patients for 3 months postoperatively.

Surgical outcome measurements

Surgical outcome measurements were generated by radiographic measurements and patient- reported outcome (PRO) measures. For radiographic assessment, spinopelvic parameters, including the SVA, sacral slope (SS), PT, PI, and LL, were measured by biplanar stereo radiographic full-body imaging (EOS imaging, Paris, France). PRO measures, including the Oswestry disability index (ODI), EuroQOL (EQ-5D), and visual analog scale (VAS) for back pain, were used to assess the surgical outcomes [19, 20]. The validated ODI (2.1a) is a self-reporting questionnaire that measures "back–specific function" on a 10–item scale, with six response categories each [20]. Each item is scored from 0 to 5, and the summation of scores for each item is converted into a percent scale. The final score does not have a unit, and no value has been established for a specific health status or change in health status. The EQ–5D is a 5–dimensional health state classification; the five dimensions are mobility, self–care, usual activities, pain/discomfort, and anxiety/depression [19, 21]. An EQ–5D "health state" is defined by selecting one level from each dimension. The EQ–5D preference–based measure can be regarded as a continuous outcome scored on a 0 to 1.00 scale, with 1.00 indicating "full health" and 0 representing death. A VAS was used to evaluate the degree of pain in the back using a 10–cm line with "no pain" and "most severe pain" on each end. The patient placed a mark on the line and the distance from the mark to zero was recorded as the VAS score. These data were collected preoperatively and reassessed at 3, 6, and 12 months after surgery.

Statistical analysis

Continuous variables were expressed as means ± standard deviations (SD). The preoperative ODI, EQ–5D, VAS for back pain, radiological parameters, and demographic data were compared between the two groups using independent t–tests. The primary outcome measure was the ODI score (mean and 95% confidence interval [CI]) at 12 months after surgery, which was compared using an independent t–test. The secondary outcome measures, including the overall ODI score, EQ–5D score, and VAS score for back pain, were assessed between the two groups during all follow–up assessments. To examine the secondary outcome measures, the main effects of the HGS group, postoperative time, and the interaction between postoperative time and HGS group on the surgical outcome measures during the follow–up period were analyzed using analysis of variance for repeated measures. Nominal categories of surgical technique were analyzed with the Chi–square test. Furthermore, we explored model selection by the Akaike Information Criterion in the multivariate regression models for prediction of ODI at 12 months after surgery. All statistical analyses were performed using the Statistical Package for the Social Sciences (version 20.0, SPSS, Inc., Chicago, IL). A p-value < 0.05 was considered statistically significant.

Results

Descriptive analysis

Of the 78 patients enrolled in this study, 52 were placed in the low HGS group and 26 were placed in the high HGS group. Post hoc analysis of the sample size revealed statistical power of 0.907. Complete surgical outcome data were available for all patients in both groups 12 months after surgery (Figure 4). The demographic data were similar in age ($p = 0.535$), sex ($p = 0.075$), and body mass index (BMI) ($p = 0.752$) between the two groups (Table 1). While the preoperative ODI scores were significantly higher in the low HGS group than those in the high HGS group ($p = 0.013$), the preoperative EQ-5D and VAS for back pain were not significantly different ($p = 0.109$). There was no significant difference in preoperative spinopelvic parameters between the two groups, with the exception of PI ($p = 0.020$) (Table 1).

The extent of instrumentation was described with two categories; fusion length and iliac screw insertion. The type of osteotomy was categorized into 3-column osteotomy (PSO or VCR) vs. PCO. The distribution of both categories was similar between the two groups (Table 1).

Table 1. Descriptive statistics of the patients before surgery

	Low HGS group (n = 52)	High HGS group (n = 26)	p-value
Age (yrs)	71.2 ± 7.6	70.1 ± 6.7	0.535
Female, (n (%))	48 (92.3%)	20 (76.9%)	0.075
BMI (kg/m^2)	25.2 ± 3.3	24.9 ± 4.7	0.752
Preoperative clinical outcome variables			
ODI	51.5 ± 15.8	42.1 ± 14.5	**0.013**
EQ-5D	0.313 ± 0.293	0.426 ± 0.289	0.109
VAS for back pain	7.7 ± 2.1	7.2 ± 2.5	0.359
Preoperative radiological parameter			
SVA (cm)	15.3 ± 8.4	14.6 ± 9.2	0.720
SS (°)	19.1 ± 11.4	16.2 ± 12.8	0.320
PT (°)	35.9 ± 11.8	33.1 ± 13.5	0.337
PI (°)	55.0 ± 10.7	48.8 ± 11.5	**0.020**
LL (°)	-2.6 ± 19.0	2.7 ± 26.2	0.316
PI – LL (°)	57.6 ± 21.9	46.1 ± 26.0	**0.044**
Extent of instrumentation			
Fusion length (levels)	9.1 ± 1.4	8.7 ± 1.6	0.260
Iliac screw (n [%])	33 (63.5%)	12 (46.2%)	**0.038**
Osteotomy			
PSO or VCR (n [%])	17 (32.7%)	10 (38.5%)	0.614
PCO (n [%])	35 (67.3%)	16 (61.5%)	

HGS: hand grip strength; BMI: body mass index; ODI: Oswestry Disability Index, Cut-off value of hand grip strength: <26 kg for men and <18 kg for women; VAS: visual analogue scale; SVA: sagittal vertical axis; SS: sacral slope; PT: pelvic tilt; PI: pelvic incidence; LL: lumbar lordosis; UIV: uppermost instrumented vertebra; LIV: lowermost instrumented vertebra; PSO: pedicle subtraction osteotomy; VCR: vertebral column resection; PCO: posterior column osteotomy

Radiological outcome analysis

Preoperatively, there was no significant difference in SVA, SS, PT, and LL between the two groups. The PI (mean ± SD) of the low HGS group (55.0 ± 10.7) was significantly larger than that of the high HGS group (48.8 ± 11.5) ($p = 0.020$), resulting in higher PI−LL values in the low HGS group than in the high HGS group ($p = 0.044$) (Table 1). At 12 months postoperatively, there was no significant difference in SVA, SS, PI, and PI−LL between the two groups (Table 2). The PT (mean ± SD) of the low HGS group (26.9 ± 8.7) was significantly larger than that of the high HGS group (22.1 ± 11.7) ($p = 0.047$) (Table 2).

Table 2. Postoperative radiological parameters between low HGS and high HGS groups

	Low HGS group (n = 52)	**High HGS group (n = 26)**	**p-value**
SVA (cm)	2.8 ± 4.2	3.6 ± 4.0	0.429
SS (°)	25.6 ± 9.8	24.1 ± 13.4	0.570
PT (°)	26.9 ± 8.7	22.1 ± 11.7	**0.047**
LL (°)	34.6 ± 17.2	35.0 ± 13.0	0.902
PI – LL (°)	18.3 ± 17.9	12.9 ± 17.6	0.214
HGS: hand grip strength; SVA: sagittal vertical axis; SS: sacral slope; PT: pelvic tilt; PI: pelvic incidence; LL: lumbar lordosis			

Surgical outcome analysis

With regards to the primary outcome, the ODI scores at 12 months postoperatively were significantly higher in the low HGS group than in the high HGS group (Figure 5). At 12 months after surgery, the mean ODI (95% CI) of the low HGS group and the high HGS group were 44.00 (39.4–48.6) and 29.0 (22.5–35.5), respectively. The difference (95% CI) was 14.7 (7.1 to 22.4; $p = 0.009$).

With regards to the secondary outcomes, the overall changes in the ODI, EQ−5D, and VAS for back pain in the 12 months after surgery were significantly different between the two groups (the effect of the HGS group on the overall changes of the ODI scores [$p < 0.001$], EQ−5D [$p < 0.001$], and VAS for back pain [$p < 0.001$]) (Figure 5, 6, 7). The effect of postoperative time on the overall changes in ODI, EQ−5D, and VAS for back pain were also significant in both groups ($p < 0.001$, $p = 0.040$, and $p < 0.001$, respectively), suggesting that these variables improved significantly with time after surgery in both groups (Figure 5, 6, 7). The effect of interactions between HGS groups and follow−up time on ODI, EQ−5D, and VAS for back pain were not significant ($p = 0.348$, $p = 0.103$, and $p = 0.235$, respectively) (Figure 5, 6, 7). Moreover, the mean treatment effect ± SD was 6.6 ± 17.9 in the low HGS group and 11.9 ± 18.7) in the high HGS group; there was no difference between the two groups ($p = 0.224$).

Figure 5. Overall change of Oswestry disability index (ODI) at follow−up assessments (preoperative, postoperative 3mo, 6mo, and 12mo) according to the low− and high−hand grip strength (HGS) groups.

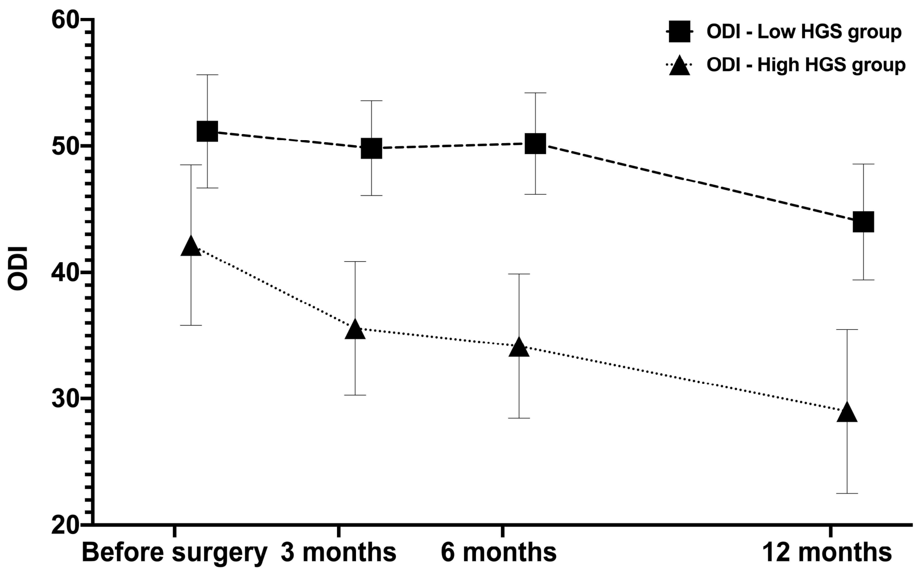


Figure 6. Overall change of EuroQOL (EQ−5D) at follow−up assessments (preoperative, postoperative 3mo, 6mo, and 12mo) according to the low− and high−hand grip strength (HGS) groups.

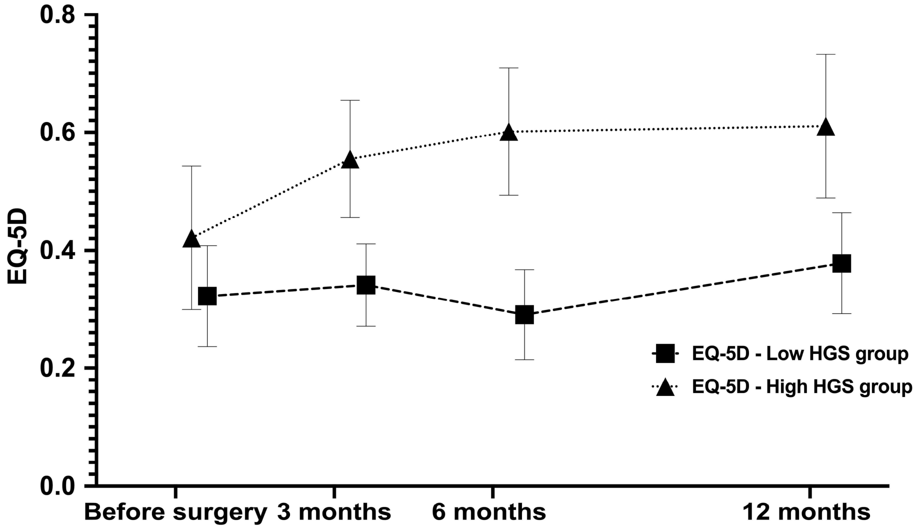
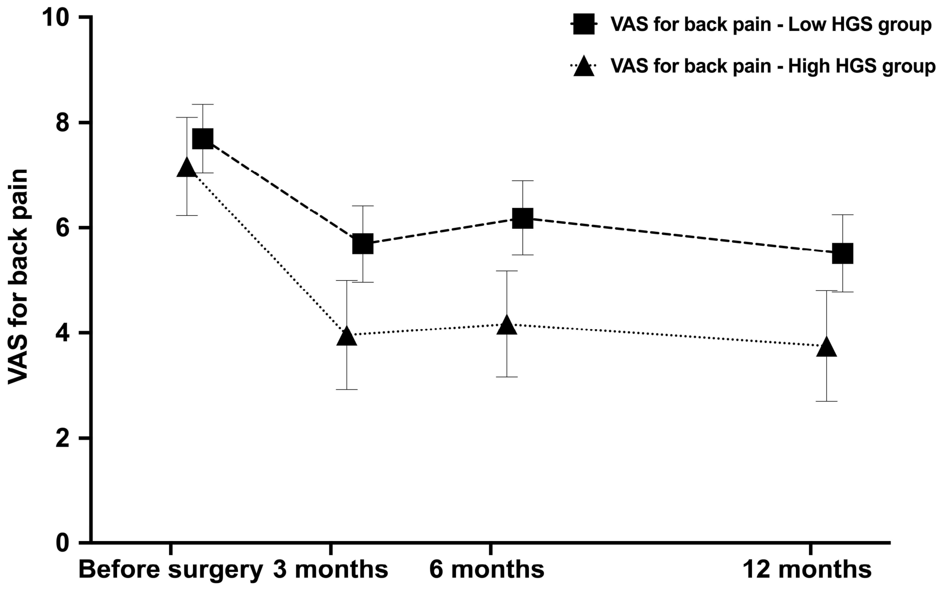


Figure 7. Overall change of visual analog scale (VAS) of back pain at follow−up assessments (preoperative, postoperative 3mo, 6mo, and 12mo) according to the low− and high− hand grip strength (HGS) groups.



Multivariate regression analysis for model prediction

Table 3 demonstrated the predictive multivariate regression models for ODI scores at 12 months postoperatively. Given the values of Akaike Information Criterion of each model, the model that consisted of demographic data, HGS, and preoperative ODI was best predictive model for ODI scores at 12 months postoperatively.

Table 3. Predictive multivariate regression models for ODI scores at 12 months postoperatively

	Adjusted R2	AIC	Covariates	Beta coefficient	p-value
Model 1	0.144	554.7			0.004
			Age	0.223	0.039
			Gender	0.182	0.138
			BMI	0.067	0.532
			HGS	-0.395	0.002
Model 2	0.151	554.0			0.003
			Age	0.174	0.107
			Gender	0.038	0.720
			BMI	0.024	0.826
			Pre ODI	0.372	0.001
Model 3	0.216	549.1			0.003
			Age	0.177	0.088
			Gender	0.1855	0.115
			BMI	0.003	0.980
			Pre ODI	0.305	0.007
			HGS	-0.318	0.010

HGS: hand grip strength; BMI: body mass index; ODI: Oswestry D isability Index, AIC: Akaike Information Criterion,

Discussion

In this observational study, we found out that HGS can be a predictor for clinical outcomes after corrective surgery for ASD. The ODI scores at 12 months after surgery were significantly lower in the high HGS group than in the low HGS group. But since both groups showed significant improvement of ODI scores with time after surgery, both groups gained benefit of improving disability from the ASD surgery. However, it is noteworthy that postoperative ODI score was far more than 22 in both groups, which is considered as the compatible score with normal life. There would be various reasons for this finding including old age > 70, high level of preoperative ODI score, and chronic low baseline functional status by spinal deformity. The EQ−5D score, implying functional status of the patients, showed more noticeable results. While it did not differ preoperatively, there was a significant difference of EQ−5D scores between the two groups with time after surgery, implying a better health−related quality of life in the high HGS group across the follow−up assessment after surgery.

These differences of surgical outcomes would not be due to the difference in amount of surgical correction between the two groups. Even though the preoperative PI−LL value was significantly different in both groups, there was no significant difference of PI−LL after surgery. Other radiological spinopelvic parameters including SVA, SS, and LL were also not different between the two groups after surgery. Moreover, the surgical technique utilized in the two groups were of similar manner. The fusion length had no difference between the two groups, and the proportion of patients who needed 3 column osteotomies to correct the sagittal imbalance also had no difference between the two groups.

The present results are in line with those of a previous study performed on degenerative lumbar spinal stenosis patients [14]. HGS has been previously proposed to have a predictive value in surgical outcome, as well as in postoperative complication rates, length of hospital stay, and re-admission rate, not only in orthopedic surgery but also in other divisions such as cardiothoracic surgery and general surgery [14, 17, 22, 23]. The results of the current study extend those of previous studies, and given that HGS is a simple, reproducible, and objective measurement, HSG would be a strong candidate for use as a predictor for surgical outcomes in clinical circumstances. Furthermore, as low HGS showed significantly higher ODI scores preoperatively, preoperative ODI score had also significant association with ODI scores at 12 months postoperatively. Finally, the multivariate model including age, sex, BMI, HGS, and preoperative ODI scores was the best predictive model for ODI scores at 12 months postoperatively.

VAS for back pain improved gradually with time after surgery in both groups, whereas patients in the high HGS displayed a lower VAS for back pain than those in the low HGS group across each follow-up assessment after surgery. This is in contrast to a previous study regarding the surgical outcomes of degenerative lumbar spinal stenosis depending on HGS [14], wherein the VAS for back pain did not differ significantly between the high- and low-HGS groups. It can be explained by the fact that muscle weakness and back muscle atrophy were suggested to be one of pathologies for stooping posture in ASD patients, and HGS can be a surrogate marker for general muscle strength [24]. On the other hand, main pathophysiology of lumbar spinal stenosis is neural compression and ischemia which causes claudication and radiating pain in the lower extremities rather than back pain. Pain medications taken by the patients at 12 months postoperatively were compared between the high- and low-HGS group to remove bias for analysis of VAS for back pain (Table 4).

Table 4. Pain medication of the high- and low- HGS patient groups at 12 months postoperatively

	Low HGS group (n = 52)	High HGS group (n = 26)	p-value
NSAIDs (%)	22.4	13.8	0.349
Opioids (%)	40.8	48.3	0.521
Neuropathic pain killers (%)	51.0	44.8	0.597
%: Percentage of patients being prescribed of each medications			

Numerous factors have been previously discussed as predictive factors for surgical outcomes of ASD; however, the majority of them were either non-modifiable factors of the patient, or surgical factors that could not be adjusted to the circumstances of the deformity. For example, age, pain VAS, ODI scores, and Charlson comorbidity index are patient factors, and the number of decompression levels, number of interbody fusion levels, SVA, and other radiological measurements are surgical factors that were discussed as predictive factors of the surgical outcome. Utilizing HGS as a prognostic factor of the ASD surgical outcome can be a reference grade of the disability that the patients are experiencing, and also a scale of how much the patients would benefit from surgical intervention of the deformity. Furthermore, since hand grip is a marker of nutritional status and musculoskeletal function, it is considered a modifiable factor. Aiding patients to improve their diet and exercise, thereby increasing muscle strength, might be suggested before proceeding to surgery [25-27]. In addition, even when surgical treatment is inevitable, increasing muscle mass would result in a better quality of life according to the results of this study.

This study has several limitations. First, it had a relatively small sample size. However, even though the size was small, the study consisted of a homogeneous population of ASD with severe positive sagittal imbalance. Still, a larger study with a longer follow-up is necessary to reach a solid conclusion on the relationship between HGS and the surgical outcomes of ASD. Second, the study design was to determine whether HGS is a predictive factor for ASD surgical outcomes. More linking variables, such as lean body mass, specific muscle volume from imaging studies, or other factors showing muscle functional status, could be incorporated to examine the mechanism of functional recovery after ASD surgery and final outcomes. Third, the cut-off value for HGS used to divide patients was based on the diagnostic criteria of sarcopenia in previous studies [18], which is yet to be verified for use in patients with ASD to undergo corrective surgery.

Conclusion

In conclusion, HGS can be a predictor of surgical outcomes in ASD, in terms of disability and functional health status, and also in terms of back pain complaints at 12 months after surgery. The predictive value of HGS could be used to assist the treatment decision and to help provide information and treatment options to patients.

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국문 초록

주요단어 : 악력; 성인 척추 변형; 변형 교정 수술; 수술 후 결과
학번 : 2019-34164

목적: 연구의 목적은 악력이 성인 척추 변형의 교정 수술의 결과에 어떠한 영향을 미치는지 알아보고자 하였다.
연구 설계: 전향적 관찰 연구
환자군: 성인 척추 변형으로 교정 수술을 받기로 예정된 환자
결과 변수: Oswestry disability index (ODI), EuroQOL (EQ-5D), 허리 통증 visual analog scale (VAS)
방법: 성인 척추 변형으로 변형 교정 수술을 시행한 78명의 환자를 대상으로 하였다. 환자들은 악력 측정 결과에 따라 고 악력군 (남자의 경우 ≥ 26kg, 여자의 경우 ≥ 18 kg, n = 26)과 저 악력군 (남자의 경우 < 26 kg, 여자의 경우 < 18 kg, n = 52). ODI, EQ-5D, 허리 통증 VAS 는 수술 전에 측정되었고 수술 후 3, 6, 12개월에 측정되었다. 1차 결과 변수는 수술 후 12개월 시점의 ODI 값으로 하였다. 2차 결과 변수는 모든 시점에서의 ODI, EQ-5D, 허리 통증 VAS로 하였다.
결과: 수술 후 12개월 시점의 ODI 값은 고 악력군에서 저 악력군에 비해 통계적으로 유의하게 낮은 값을 보였다 ($p < 0.009$). 2차 결과 변수의 분석 결과, ODI score, EQ-5D, 허리 통증 VAS 모두 수술 후 시간이 경과함에 따라 호전되었지만 각각의 변수에서 모두 고 악력군에서 저 악력군에 비해 더 큰 정도의 호전을 보였다 ($p < 0.001$)
결론: 수술 전 악력이 높은 환자군에서 성인 척추 변형의 교정 수술을 시행하였을 때 수술 후 환자의 주관적인 만족도가 더 우수함을 알 수 있다. 수술의 과 값은 일상생활에서의 장애 정도와 삶의 질을 대변하는 것으로, 악력이 저하된 환자군에서는 수술적 치료의 결정에 유의하여야 함을 본 연구를 통하여 알 수 있다.