

# Trends in Medical Costs for Adolescent Idiopathic Scoliosis Surgery in Japan

Global Spine Journal  
2020, Vol. 10(8) 1040-1045  
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DOI: 10.1177/2192568219886265  
journals.sagepub.com/home/gsj



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## Abstract

**Study Design:** A retrospective review of clinical data and costs was performed for surgeries for adolescent idiopathic scoliosis (AIS) conducted from 2008 to 2017.

**Objective:** Cost containment and healthcare value have become focal points in Japanese health care policy. The purpose of the study was to investigate trends over time in medical costs for surgery for AIS.

**Methods:** A total of 83 patients underwent surgery for AIS from 2008 to 2017 at our hospital. Clinical data and length of stay were collected, and medical costs for surgery, local bone grafting, fees per day, and surgical instruments were evaluated.

**Results:** There were slight year-by-year decreases in fees per day and decreases in costs of surgical instruments. The average length of stay was 16.4 days and gradually decreased over time. In contrast, scoliosis surgery costs increased about 1.6 times in 10 years from \$9515 to \$15130.

**Conclusion:** The trends for decreases in fees per day and prices for surgical instruments reflect recent government medical cost control policies. The cost for scoliosis surgery is also defined by the government, and the increase over 10 years may reflect the perspective of valuing effective and advanced surgeries. This study of cost trends of operative spinal intervention provides an assessment of surgical benefit and is likely to influence health care costs.

## Keywords

trends, spine surgery, adolescent idiopathic scoliosis, medical costs, spinal instrumentation, health care costs

## Introduction

Medical expenses in Japan have increased yearly from \$353.9 billion in 2000 to over \$495.5 billion in 2015.<sup>1</sup> These increasing health care costs pose a significant challenge to the sustainability of the health care economy. Thus, efforts are required in current medical care to reduce expenses, such as shortening the length of hospital stay. In Japan, an all-inclusive payment system, a so-called “bundle payment,” was introduced in hospitals with specific functions in 2003. Since 2005, this method has been used in national hospitals, social insurance hospitals, and other centers. Generally, hospitalization costs in Japan include an all-inclusive payment (hospital administration fees per day, medical examination, medication, injection, diagnostic imaging) and an itemized payment (surgery, rehabilitation), with most costs determined by the government as official medical prices every two years. Cost containment and defining the

value of health care provided to patients has become a focal point in Japanese health care policy.<sup>2-4</sup> In this context, surgeons have responsibilities to society to limit costs related to spine surgery, and thus, more rigorous economic analyses of medicine and surgery are required.

Adolescent idiopathic scoliosis (AIS) is a 3-dimensional spinal deformity that results in physical and psychosocial impairment, including poor self-image, low self-esteem, and back pain.<sup>5-7</sup> The primary goals of surgical treatment of AIS

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are to obtain curve correction, to prevent curve progression, and to achieve a balanced spine in the coronal and sagittal planes. Numerous studies have shown the clinical and radiographic benefits of spinal arthrodesis and instrumentation to treat progressive AIS.<sup>8-12</sup> Surgical techniques for AIS continue to evolve, and surgical treatment has expanded greatly. Currently, posterior fixation with a pedicle screw is widely performed for AIS, since use of pedicle screws reduces the rate of revision surgery and improves radiographic and clinical outcomes.<sup>13</sup> Blood salvage techniques and spinal cord monitoring are now also standard methods in surgery for AIS.<sup>14-18</sup>

These recent technological advances have added new procedures in surgery, with a resultant increase in medical costs. The cost-effectiveness of many spinal surgeries has been reported, but there has been less attention to the surgical costs themselves.<sup>19,20</sup> In an effort to understand the value of operative management, we investigated operative resource utilization and the cost of treatment for AIS. There has been no previous report on the medical economics of AIS surgery in Japan. The purpose of this study was to evaluate the total treatment costs and medical bundle payments in spinal surgery for AIS and to investigate trends over time.

## Materials and Methods

The subjects of the study were 83 patients (3 males, 80 females) who underwent surgery for AIS using a posterior only approach with pedicle screw instrumentation in a prone position with a one-stage procedure at our hospital from January 2008 to December 2017. Cases treated with anterior surgery, anterior and posterior combination surgery, or surgery for syndromic or congenital scoliosis were excluded.

The mean age at the time of surgery was 14.6 years (11-19 years). Preoperative motor status and comorbidities were not used as exclusion criteria. Demographic, radiographic, and surgical data were collected for each patient. Pre- and postoperative scoliosis was measured using the Cobb method. Curves were classified with the Lenke system.<sup>21</sup> This study was approved by the ethical committee of our hospital.

In all 83 cases, intraoperative brain-evoked muscle-action potentials (Br(E)-MsEPs) were recorded for spinal cord monitoring. Pedicle screws were inserted and polyethylene tape was simultaneously passed under the lamina. All vertebrae were held by pedicle screws or tapes. After local bone graft, rods bent into a good sagittal alignment were located on the concave side and correction was performed through a rotation maneuver. Ponte osteotomy was performed if required. Distraction was applied to the pedicle screws and the concave side of the curve was corrected. For the convex side, the rods were located in situ after local bone graft, and correction was performed by applying compression between the pedicle screws.<sup>22,23</sup>

A retrospective analysis of the AIS surgeries was performed using clinical data for fusion range, number of screws, screw density, operative time, estimated blood loss (EBL), length of hospital stay (LOS), and cost of hospitalization and surgical treatment of AIS over 10 years. Screw density was calculated

**Table 1.** Demographic and Surgical Data (n = 83).<sup>a</sup>

Item	Value
Demographic data	
Age (years)	14.6 ± 2.2
Female, n (%)	80 (96)
Height (cm)	154 ± 9.1
Lenke classification, n (%)	
Type 1	22 (27)
Type 2	15 (18)
Type 3	9 (10)
Type 4	4 (5)
Type 5	21 (25)
Type 6	12 (14)
Preoperative Cobb angle (major curve) (deg)	54.7 ± 14.5
Preoperative traction Cobb angle (major curve) (deg)	24.3 ± 10.1
Procedural variables	
Operative time (min)	287 ± 78
Estimated blood loss (mL)	776 ± 551
Outcome	
Postoperative Cobb angle (deg)	11.9 ± 7.5
Correction rate (%)	75.3 ± 12.4
Length of stay (days)	16.4 ± 2.2

<sup>a</sup>Data are shown as mean ± standard deviation or number (percentage).

as the total number of screws in the construct divided by the fusion range.<sup>24</sup> Trends were examined for the costs for scoliosis surgery, local bone grafting, hospital administration fees per day, and surgical instruments, all of which are determined by the government every 2 years. Based on these data, the total treatment cost per patient per year was calculated.

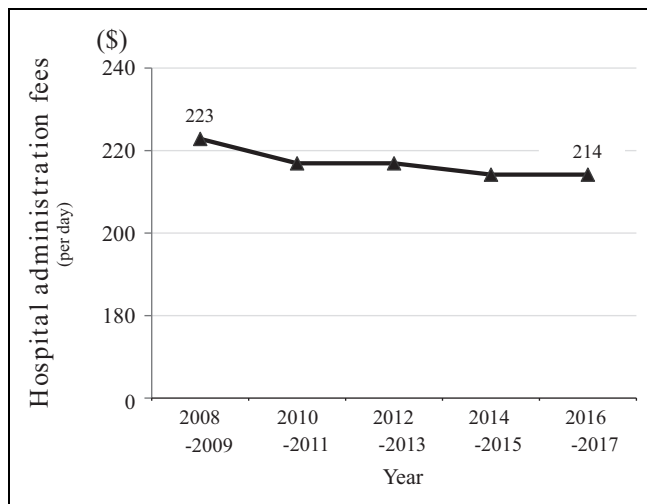
## Results

The preoperative characteristics of the patients are shown in Table 1. The Lenke types were 1 (n = 22), 2 (n = 15), 3 (n = 9), 4 (n = 4), 5 (n = 21), and 6 (n = 12). Preoperatively, the mean Cobb angle was 54.7° (43°-96°) and the manual traction Cobb angle was 24.3° (6°-73°). Surgery was performed in 22 cases in 2008-2009, 10 cases in 2010-2011, 19 cases in 2012-2013, 13 cases in 2014-2015, and 19 cases in 2016-2017. Postoperatively, the mean Cobb angle was 11.9° (1°-41°) and the correction rate was 75.3% (45.0%-97.6%). The average operation time was 287 minutes (159-606 minutes) and the average EBL was 776 mL (85-3300 mL). The average fusion range was 10.0 (6-15) levels, and was 9.8 levels in 2008-2009, 10.0 levels in 2010-2011, 9.6 levels in 2012-2013, 10.3 levels in 2014-2015, and 10.4 levels in 2016-2017. For instrumentation, 14.7 screws were used per patient in 2008-2009, 15.1 in 2010-2011, 14.1 in 2012-2013, 15.3 in 2014-2015, and 16.1 in 2016-2017. The mean screw density was 1.51 screws per fusion range, with a range of 1.47 to 1.59 screws (Table 2). The average LOS was 16.4 days (11 to 22 days). None of the patients had intra- or postoperative neurological sequelae. All patients received preoperative autologous blood donations and postoperative blood transfusion. There were no postoperative neurological deficits.

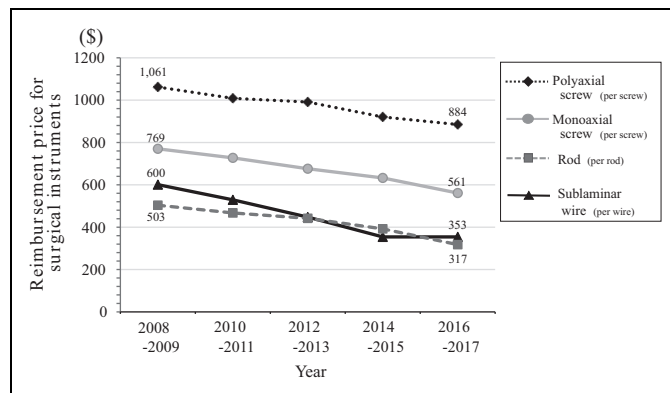
**Table 2.** Changes in Fusion Range, Number of Screws, and Screw Density Over Time.

Year	Patients (n)	Fusion Range	Number of Screws	Screw Density <sup>a</sup>
2008-2009	22	9.8	14.7	1.50
2010-2011	10	10.0	15.1	1.51
2012-2013	19	9.6	14.1	1.47
2014-2015	13	10.3	15.3	1.49
2016-2017	19	10.4	16.1	1.59
Total	83	10.0	15.1	1.51

<sup>a</sup>Screw density is reported per vertebral level.



**Figure 1.** Trend in hospital administration fees per day over time.



**Figure 2.** Trends in individual reimbursement prices for surgical instruments over time.

As medical costs are stipulated by the Ministry of Health, Labour and Welfare (MHLW), there were slight year-by-year decreases in hospital administration fees per day (Figure 1). There were also decreases in costs of surgical instruments such as screws, rods, and sublaminar wire (Figure 2), for which the reimbursement price is also defined by the government. LOS

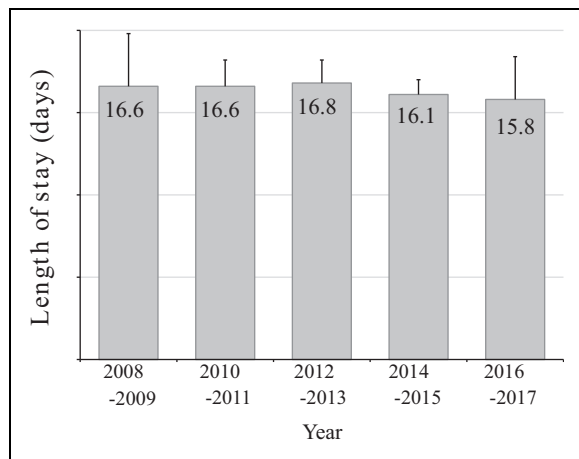
also gradually decreased over time (Figure 3). In contrast, scoliosis surgery costs, which are also determined by the MHLW, increased about 1.6 times in 10 years (from \$9515 to \$15 130) and the local bone grafting cost also increased (Figure 4). The proportion of the total cost occupied by surgical costs also increased over time (Figure 5). The surgical costs included those for implants, anesthesia, intraoperative spinal monitoring, blood transfusion, and intraoperative drugs. These costs increased over the study period, except for the reimbursement price of surgical instruments, which were included as part of the surgical cost.

### Discussion

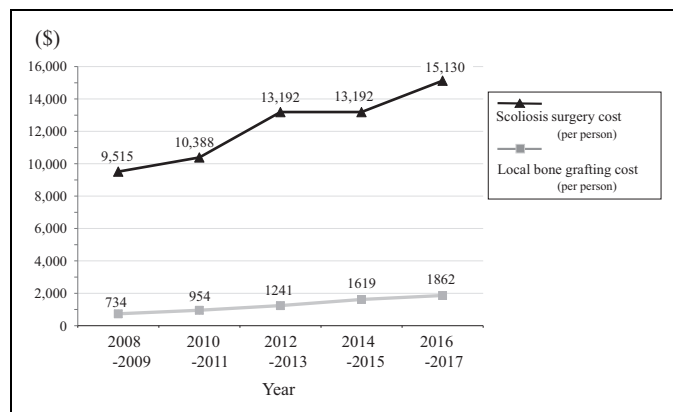
The Diagnosis Procedure Combination (DPC) was introduced for “bundle payment” of medical expenses in Japan in 2003.<sup>25,26</sup> The DPC was first used for acute inpatient medical care and was then introduced for hospitals with specific functions. By 2015, the DPC is used for about 55% of all general hospital beds in Japan.<sup>27</sup> The DPC calculation determines an all-inclusive payment based on classification of the “diagnosed disease.” This is distinct from the “itemized payment”, for which the cost is calculated for each medical procedure. In general, based on the diagnosed disease determined by the MHLW, both the all-inclusive payment (injection, medication, treatment, examination, imaging diagnosis, hospitalization fee, etc) and the itemized payment (surgery, anesthesia, rehabilitation, etc) are included in the total cost. Thus, even if medications, injections, and diagnostic imaging are widely used, the all-inclusive payment does not change. However, surgery and rehabilitation expenses are calculated in an itemized manner.

There have been few previous studies of the cost of scoliosis surgery. In a retrospective review of hospital costs for surgical treatment of AIS, Kamerlink et al<sup>28</sup> found that these costs ranged from \$29 955 to \$60 754, with the main contributors being implants used, intensive care unit stays, operating room time, and bone graft use. Correlations of general costs and surgery costs with reimbursement for primary surgical treatment of AIS showed that reimbursement was most closely linked with surgery costs.<sup>28</sup> Bhat et al<sup>29</sup> estimated an annual savings of US\$11 to \$20 million by changing from all pedicle screws to an alternating screw pattern, and Yang et al<sup>30</sup> found a significant positive association between increased spending on implants per level fused and the % Cobb angle correction. However, no reports have examined the details of medical expenses determined by governments over time, such as the reimbursement price of surgical instruments and hospital administration fees.

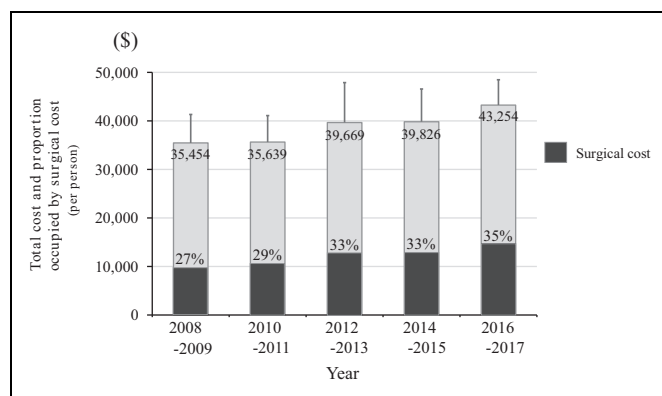
Orthopedic surgery, and especially spinal surgery, is an implant-intensive specialty, which contributes significantly to the total cost of care. Surgeons are constantly trying to improve operative care and often recognize potentially useful adaptations in techniques or implants. Market forces are likely to continue to affect the cost of implants, and collaborative efforts among industry, individual hospitals, and institutions are needed to help curtail rising costs. In the setting of rapid and



**Figure 3.** Trends in length of stay over time.



**Figure 4.** Trends in scoliosis surgery costs and local bone grafting costs per person, as defined by the Ministry of Health Labour and Welfare.



**Figure 5.** Trends in total treatment costs and proportion occupied by surgical costs per person.

unsustainable increases in costs of care, surgeons and hospitals need to work in alignment to be aware of costs and to consider the impact of implant costs on the overall value of care. In Europe and America, competitive group pricing is a common

strategy used to reduce the cost per implant.<sup>31-33</sup> In contrast, Japan has used public health insurance since 1961, under which all people receive equal medical treatment, and reimbursements for medical materials and medical costs have been calculated by the MHLW every two years. In particular, there is no variability in the cost of surgical implants between hospitals and manufacturers in Japan, and the total medical costs that can be billed to a patient do not differ among hospitals.

In our series, trends for a slight decrease in costs such as hospital fees per day and a substantial decrease in reimbursement prices for surgical instruments reflect recent medical cost control policies of the government. However, the cost for scoliosis surgery defined by the MHLW increased by about 1.6 times in 10 years, and the proportion of surgical costs in the total treatment cost also increased. These changes may reflect the viewpoint of the MHLW in valuing advanced surgical procedures with good outcomes under current economic conditions. An investigation of the cost trends of operative spinal intervention provides a useful assessment of the treatment benefit and is likely to influence health care costs.

The average LOS in our series was 16 days, which is longer than that in most countries, in which most patients are discharged from hospital in less than 1 week. Our patients were admitted a few days before surgery for whole body screening, and hospital discharge occurred after removal of the wound suture and confirming the wound condition at about 10 days after surgery. Thus, our LOS was significantly longer than the standard LOS worldwide. There were no neurological deficits before surgery and no cases with motor deficit after surgery; therefore, the rehabilitation period was short and there was no increase in postoperative rehabilitation costs.

There are several limitations in this study. Relatively few surgeries were included because our facility is a national university hospital. In particular, the analysis focused only on AIS conducted with a posterior approach over a short period of 10 years, and with examination of hospitalization costs only, without considering outpatient clinical practice. Also, the medical costs used in the study are the total costs during hospitalization, and there is a large gap from the amount paid by the patient, who pays only a bed fee and a meal fee due to preferential treatment of pediatric patients in Japan. However, although it is difficult to investigate individual details in comprehensive medical care, this study is the first report of Japanese medical cost variability in AIS, and it may reflect the current medical economy in Japan, as the fastest aging society worldwide. Also, in a longitudinal study in one hospital, variation of confounding factors such as operating room protocols, surgical instrumentation, evolving surgical and anesthetic techniques, differences in trainee skill level, and postoperative pain regimens and rehabilitation protocols are likely to be small. Therefore, this study provides a unique contribution to the clinical experience of management of AIS.

### Conclusion

This investigation of the medical costs involved in AIS surgery revealed a trend that reflects the problem of medical

economics. In Japan, universal insurance is available for all people and the self-payment amount is low. Medical expenditures in Japan have increased significantly with aging, and about half of all medical expenses are paid from sources other than insurance premiums, since about half of the national budget revenue is from government bond issuance. Reduced all-inclusive payments, such as hospital administration fees per day, and a substantial decline in reimbursement prices for surgical instruments reflect recent medical cost control policies in Japan. In contrast, itemized costs related to surgery are increasing with technological advances. These competing trends provide a challenge for the health care economy, and spine surgeons need to understand medical costs, including those for surgeries. Our study of cost trends in operative spinal intervention provides an assessment of surgical benefit and is likely to influence health care costs.


### Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

### Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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