SHORT COMMUNICATON

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Changes in medical costs for adolescent idiopathic scoliosis over the past 15 years

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ABSTRACT

Use of instrumentation has become widespread in spinal surgery due to intraoperative spinal cord monitoring, navigation, and improvement and development of implant materials. However, recent advances in spine surgery may have also led to an increase in medical costs. The purpose of this study is to investigate the trends of operative resource utilization and the costs of surgery for adolescent idiopathic scoliosis (AIS) over 15 years. Surgery for AIS was performed for 118 patients from January 2004 to December 2019 at national University Hospital. Trends were examined through retrospective calculation of the costs for outpatient, inpatient, and surgical services, and changes over time and the characteristics of fees were examined. Differences between groups were analyzed by Mann-Whitney U test and Student t-test. During the 15-year period, the length of hospital stay decreased, but costs for scoliosis surgery increased by 1.6 times and the total cost increased by 1.3 times. The fee for intensive care per day per person increased by 1.5 times. There were slight increases in MRI and CT fees, but no changes in fees for radiography, rehabilitation, subsequent visits, and prescriptions. New charges for medical supervision, medical clerk support, medical safety measures, and prevention of infection were added at different times during the 15-year period. Itemized costs related to surgery have increased with technological advances. Although these results only show changes in costs for AIS surgery, the findings indicate the challenges faced by the healthcare economy and the need for spine surgeons to understand medical costs.

Keywords: medical costs, trends, spine surgery, adolescent idiopathic scoliosis, spinal instrumentation

Abbreviations:
AIS: adolescent idiopathic scoliosis
MHLW: Ministry of Health, Labour and Welfare

INTRODUCTION

Cost for medical care in Japan have increased from $353.9 billion in 2000 to more than $453.0 billion in 2017[1] and these costs are a major economic concern for healthcare sustainability. The

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so-called “bundle payment”, an all-inclusive payment system, was introduced in certain hospitals in Japan in 2003, and national hospitals, social insurance hospitals, and other centers have used this system since 2005. An all-inclusive payment for daily administrative fees, examinations, drugs, and imaging, and itemized payments covering surgery and rehabilitation are used for the costs of hospitalization, with these costs mostly determined officially by the government on a two-yearly basis. Cost containment and defining healthcare value for patients are now focal points in Japanese healthcare policy.[2-5]

Adolescent idiopathic scoliosis (AIS) is a deformity of the spine that causes physical impairment that may lead to back pain and psychosocial difficulties that include lowered self-image and self-esteem.[6-8] Surgery for AIS is performed to correct or prevent progression of curvature of the spine, and to achieve spinal balance in the coronal and sagittal planes. Surgical treatment for AIS has evolved and expanded, and currently posterior fixation with a pedicle screw is commonly used because this procedure reduces revision surgeries and improves radiographic and clinical outcomes.[9] In recent years, use of instrumentation in spinal surgery has become widespread with advances in intraoperative spinal cord monitoring, navigation, and implant materials, with similar trends observed worldwide.

These recent advances in surgery have led to a corresponding increase in medical costs. Many spine surgeries have been found to be cost-effective, but the surgical costs themselves have received less attention.[10,11] Therefore, we examined resource utilization in surgery and treatment costs for AIS, with the goal of defining the value of operative management.

Hospitalization costs in Japan generally 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. In the current study, a series of reimbursement prices for spine surgery were calculated for outpatient, inpatient, and surgical services, and the changes over time and the characteristics of the reimbursement were examined. The details of all costs related to treatment and the costs for examination, surgery and hospitalization were then calculated individually.

MATERIALS AND METHODS

Surgery for AIS was performed for 118 patients, of whom 110 were females, in the period January 2004 to December 2019 at national University Hospital. A one-stage posterior only approach was used with a pedicle screw and the patient in a prone position. Cases that underwent anterior surgery, a combination of anterior and posterior surgery, and surgery for syndromic or congenital scoliosis were excluded. Motor status before surgery and comorbidities were not evaluated as exclusion criteria. Normally, MRI and CT scans were recorded only once before surgery and once after surgery. A team-based treatment approach was used and there were no major changes in the treatment policy during the study period. The study was approved by the institutional ethical committee.

Demographic, radiographic, and surgical data were reviewed for each case. The Cobb method was used to determine pre- and postoperative scoliosis, with curves classified using the Lenke system.[12] Spinal cord monitoring using intraoperative brain-evoked muscle-action potentials (Br(E)-MsEPs) was performed in all cases. Insertion of pedicle screws with simultaneous passing of polyethylene tape under the lamina was performed for all vertebrae. Following local bone graft, rods bent into a good sagittal alignment were positioned on the concave side and rotation was performed to achieve correction. Ponte osteotomy was used if required. Distraction was applied to the pedicle screws for correction of the concave side of the curve. For the convex side, the

rods were located in situ following local bone graft, and compression between the screws was used for correction.[13,14]

The surgeries for AIS were evaluated retrospectively based on the fusion range, number of screws, screw density, operative time, estimated blood loss (EBL), and cost of hospitalization and surgical treatment of AIS for 15 years. Trends were examined for the costs of scoliosis surgery, local bone grafting, hospital administrative fees (intensive care, acute hospitalization) per day, fee for first visit per day, rehabilitation fee per day, subsequent visit fee per day, prescription fee per day, fee associated with imaging tests (MRI, CT, roentgenography) per person, and new charges associated with spine surgery care per person. 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. Hospitalization costs in Japan generally 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. Cost containment and definition of the value of healthcare provided to patients has become a focal point in Japanese health care policy. All fees are determined by the government every two years.

Statistical analysis was performed to evaluate changes in the characteristics of AIS surgery over the study period. Differences between two groups were analyzed by Mann-Whitney U test and Student t-test, using SPSS ver. 22 for Windows (IBM, Chicago, IL). $P<0.05$ was considered to be significant in all analyses.

RESULTS

The preoperative characteristics of the patients are shown in Table 1. The mean age of the 118 patients at the time of surgery was 14.9 years (range 10–19 years). Surgery was performed in 10 cases in 2004–2005, 12 in 2006–2007, 22 in 2008–2009, 10 in 2010–2011, 19 in 2012–2013, 13 in 2014–2015, 19 in 2016–2017, and 13 in 2018–2019. The pre- and postoperative mean Cobb angles were 54.9° (range 43°–96°) and 10.8° (1°–41°), respectively, and the correction rate was 80.3% (45.0%–97.6%) (Table 1). The number of patients, fusion range, number of screws, and screw density for each year are shown in Table 2. Over 15 years, the mean fusion range was 9.9 levels, and 15.3 screws were used per patient at a density of 1.54 screws per fusion range, with little variation from year to year. Preoperative autologous blood donation and postoperative blood transfusion were performed in all cases. There were no postoperative neurological deficits.

Regarding costs defined by the Ministry of Health, Labour and Welfare (MHLW) during the 15-year period, fees for scoliosis surgery and for local bone graft both increased steadily. Costs for scoliosis surgery increased from $3283 to $5278 (about 1.6 times) and those for local bone grafting increased from $783 to $1588 (about 2.0 times) in 15 years (Figure 1).

There was a slight increase in first visit fees and the fee for acute hospitalization, and the fee for intensive care per day per person increased by 1.5 times (Figure 2). There was a slight increase in MRI and CT fees, but radiography fees remained the same (Figure 3). There were no increases in the fees for rehabilitation, subsequent visits, and prescriptions (Figure 4). However, a charge for medical supervision was added, followed by charges for a medical clerk in 2006, for medical safety measures in 2008, and for prevention of infection in 2012 (Figure 5). There were decreases in costs of surgical instruments such as screws (Figure 6). The proportion of surgical costs among the total costs also increased over time (Figure 7) and showed a significant increase in 2018–2019 compared to 2004-2005 ($p<0.05$).

Table 1 Demographic and operative data (n=118)

Factor	Total (n=118)	Period		
		2004-2008 (n=32)	2009-2013 (n=41)	2014-2019 (n=45)
Demographic data				
Age (years)	14.9±2.5	14.1±2.4	14.9±2.6	15.4±2.3
Female (n)	110 (93%)	29 (91%)	39 (94%)	42 (93%)
Height (cm)	155.4±8.2	153.5±8.0	156.2±8.3	156.0±8.4
Body weight (kg)	47.5±8.9	46.1±8.5	48.2±8.9	47.8±9.0
Lenke classification (n)				
Type 1	35 (30%)	10 (29%)	11 (31%)	14 (40%)
Type 2	21 (18%)	5 (24%)	7 (33%)	9 (43%)
Type 3	13 (11%)	3 (23%)	6 (46%)	4 (31%)
Type 4	6 (5%)	2 (33%)	1 (17%)	3 (50%)
Type 5	29 (25%)	8 (28%)	11 (38%)	10 (34%)
Type 6	14 (12%)	4 (29%)	5 (35%)	5 (36%)
Preoperative Cobb angle (major curve) (°)	54.9±14.1	52.2±13.9	55.1±14.0	56.4±14.4
Procedural variables				
Operative time (min)	297±82	289±80	299±83	301±85
Estimated blood loss (mL)	763±547	748±526	776±551	762±547
Outcome				
Postoperative Cobb angle (°)	10.8±7.1	10.1±6.3	12.2±6.8	10.0±7.2
Correction rate (%)	80.3±11.7	80.9±12.6	78.3±11.4	81.7±12.3
Average length of stay (days)	20.6±9.8	22.4±9.4	20.9±10.1	19.0±9.7
Postoperative surgical site infection	2 (1.6%)	1 (1.6%)	1 (1.6%)	0 (0%)

Data are shown as the mean ± standard deviation or a number.

Table 2 Trends in fusion range, number of screws, and screw density over time for 15 years

Year	Patients (n)	Fusion range	Number of screws	Screw density*
2004–2005	10	9.5	15.2	1.60
2006–2007	12	10.2	15.9	1.56
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
2018–2019	13	9.7	15.9	1.64
Total	83	9.9	15.3	1.54

*Screw density is reported per vertebral level.

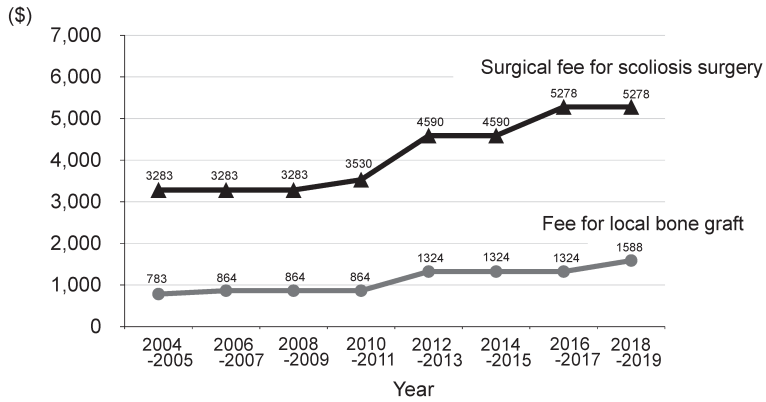

Fig. 1 Trends in fees for scoliosis surgery and local bone graft per person, as defined by the Ministry of Health, Labour and Welfare

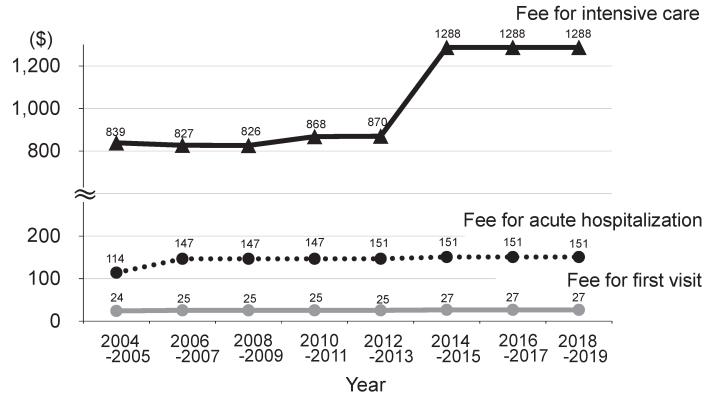

Fig. 2 Trends in individual reimbursement fees for intensive care, acute hospitalization, and first visit per person per day over time

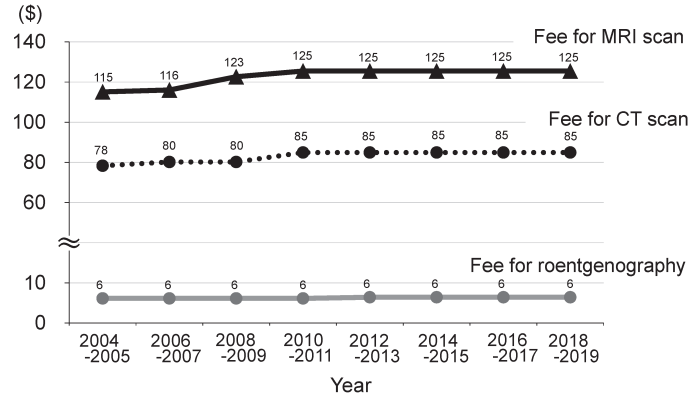

Fig. 3 Trends in fees associated with imaging tests (MRI, CT, roentgenography) over time

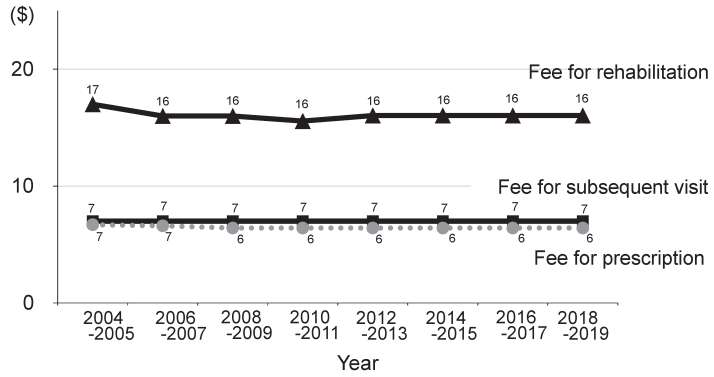

Fig. 4 Trends in fees for rehabilitation, subsequent visits, and prescriptions per person over time

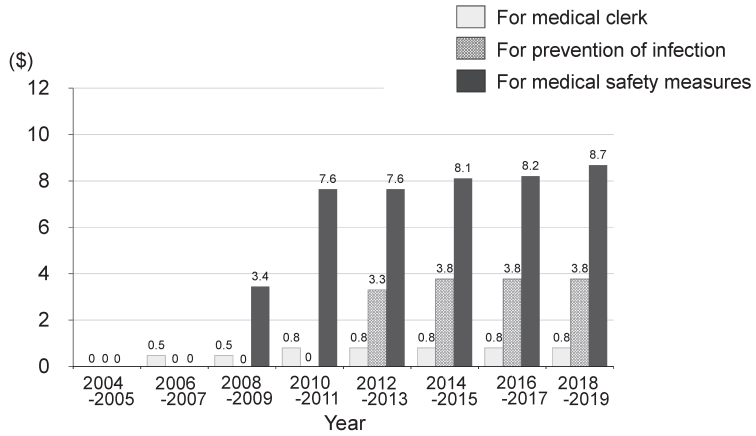

Fig. 5 Trends in new charges associated with spine surgery care (medical clerk, prevention of infection, medical safety measures) per person

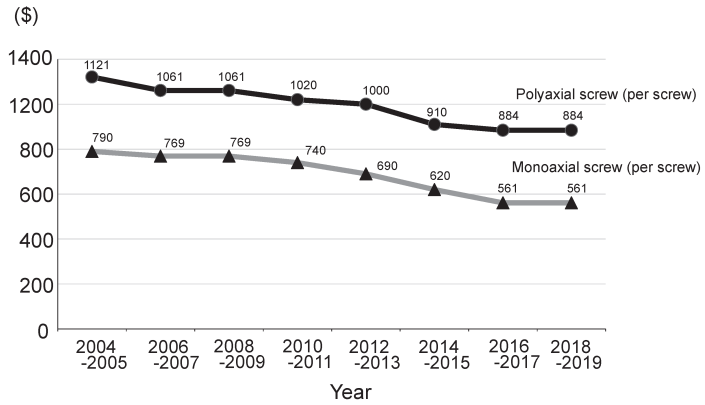

Fig. 6 Reimbursement price for surgical instruments

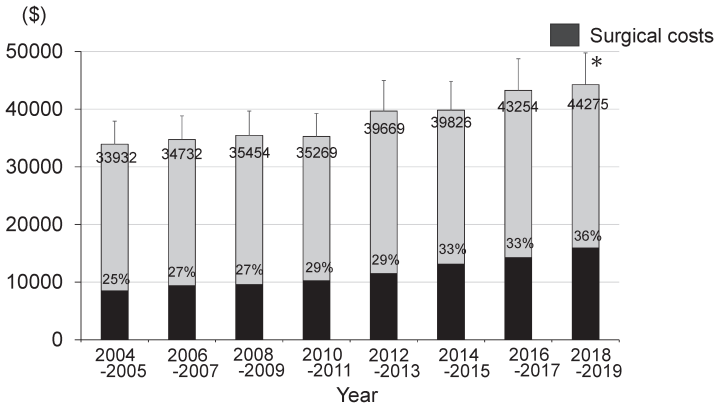

Fig. 7 Total costs and proportion due to surgical costs (per person)
*p<0.05 for 2004–2005 vs 2018–2019

DISCUSSION

The Diagnosis Procedure Combination (DPC) for "bundle payment" of medical expenses was introduced in Japan in 2003.[15,16] and by 2015 this system was used for about 55% of general hospital beds.[17] Using the DPC, an all-inclusive payment is calculated based on the classified "diagnosed disease". This approach is distinct from that using an "itemized payment" for the cost of each medical procedure. The diagnosed disease determined by the MHLW is used to establish a total cost, which is calculated from the all-inclusive (drugs, treatment, examination, imaging, hospital fees, etc) and itemized (surgery, anesthesia, rehabilitation, etc) payments. Thus, the all-inclusive payment is unchanged, regardless of the usage level of drugs and imaging, whereas surgery and rehabilitation expenses are itemized.

Evaluation of the costs of AIS surgery is particularly important because most patients who undergo this surgery are younger (10 to 20 years old) than those treated for other diseases, and most have no serious medical history. Therefore, the postoperative course until discharge is normally very good and there are few postoperative complications. There have also been few reports focusing on this surgery to date. In a retrospective review, Kamerlink et al[18] found hospital costs of $29,955 to $60,754 for surgery for AIS, with implants, intensive care unit (ICU) costs, time in the operating room, and bone grafts being the most important elements. Reimbursement for primary surgical treatment of AIS is more closely linked to surgery costs, rather than general costs.[18] Increased spending on implants per level fused has been found to be positively related to the % Cobb angle correction.[19] However, the details over time of government-determined medical costs, such as surgical costs and hospital administration fees, have not been examined.

Orthopedic surgery is a specialty that is implant-intensive, and this is a major contributor to the total cost of care. This is especially true of spine surgery, and surgeons improve operative care through adaptations in techniques or implants. Competitive group pricing is a common strategy used in Europe and the United States to reduce the cost per implant.[20-22] In contrast, Japan has used public health insurance since 1961, through which all people receive equal treatment, and cost reimbursements are calculated by the MHLW every two years. The cost of surgery, including implant surgery, does not vary widely among hospitals and manufacturers in Japan, and there is no difference among hospitals in the total costs charged to patients. The self-payment amount is low because universal insurance is available for the whole population.

In this study, the fees for hospitalization, first visit, and rehabilitation barely increased over time, and thus, the trends reflect recent government policies aimed at control of medical costs. These results may be due to these aspects of treatment not being directly involved in the surgical procedure. Over the past 15 years, costs for outpatient consultations, prescriptions, and imaging tests have generally remained unchanged. In addition, the price of the screw was found to have decreased over the years, and the delivery price has also decreased. There was essentially no change in the indications in the surgical plan over the last 15 years. However, the MHLW-defined costs for scoliosis surgery have increased by about 1.6 times over 15 years, and fees for intensive care have increased by 1.5 times in 15 years. The total medical expenses for this surgery also increased, despite the decrease in the length of the hospital stay. Surgical procedure and ICU management fees have increased, and additional costs for medical safety measures and physician administrative support systems have been added. These changes reflect fees for surgeries and postoperative management requiring a high level of expertise, ensuring medical safety, and reducing the workload of physicians. An understanding of these issues is very important to the surgeon. The changes may reflect the value the MHLW places on advanced surgery with good outcomes, under current economic conditions. An understanding of the trends of costs for surgical spinal intervention is useful for assessment of the treatment benefit and is likely to have an influence on healthcare costs.

This study has several limitations. First, the number of cases was limited because the facility is a national university hospital and we focused on AIS treated with a posterior approach over a relatively short 15-year period. Second, the costs examined were mainly those for hospitalization, during which a pediatric patient pays only bed and meal fees due to preferential treatment of these patients in Japan. The cost to the patient was mainly examined in this study, and the details of other indirect costs (ie, round-trip costs to medical institutions, and time and cost required of the family to allow the patient to receive medical care) were not examined. Third, among spinal surgeries, the number of AIS surgeries is relatively small and there is no evidence that AIS itself has led to an increase in medical costs. We did not investigate trends in spinal surgeries other than for AIS. However, despite the lack of details of medical care, this is the first report of Japanese medical costs in AIS and may reflect the current medical economy in Japan, as the most rapidly aging society worldwide. We also note that a longitudinal study in one hospital has an advantage of low variation of confounding factors, including operating room protocols, surgical and anesthetic methods, pain regimens after surgery, and rehabilitation protocols. Therefore, the results of this study provide a unique understanding of the costs and clinical approach to management of AIS.

CONCLUSION

The results of this study show that itemized costs related to surgery have increased with technological advances. The increase in intensive care fees and the establishment of additional charges for medical safety measures and for physician support systems reflect the desire for surgical procedures and postoperative management that require a high level of expertise, as well as ensuring medical safety and reducing the workload of physicians. This examination of medical costs in AIS surgery revealed trends that reflect problems in medical economics. These trends are a challenge for the healthcare economy and show the importance of spine surgeons understanding medical and surgical costs.

DISCLOSURE STATEMENT

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