National trends and in-hospital outcomes in patients with rheumatoid arthritis undergoing elective atlantoaxial spinal fusion surgery

H. Yoshihara[1,2], D. Yoneoka[3], A. Margalit[1]

[1]Department of Orthopaedic Surgery and Rehabilitation Medicine SUNY Downstate Medical Center, NY, USA; [2]Department of Orthopaedic Surgery, Nagoya City University Graduate School of Medical Sciences, Japan; [3]Department of Statistical Sciences, School of Advanced Sciences, The Graduate University for Advanced Studies, Tokyo, Japan.

Abstract

Objective

Atlantoaxial subluxation is a well-known cervical spinal disorder in rheumatoid arthritis (RA) and certain patients with this condition may need to receive atlantoaxial spinal fusion (AASF). However, there is limited information available regarding demographics and outcome trends. The purpose of this study is to present an analysis of RA patients who underwent elective AASF using national in-hospital data.

Methods

Clinical data were derived from the US Nationwide Inpatient Sample (NIS) between 2000 and 2009. Patients who had a diagnosis of RA and underwent elective AASF, total hip arthroplasty (THA), and total knee arthroplasty (TKA) were identified. Data regarding patient- and healthcare system-related characteristics, comorbidities, in-hospital complications, and mortality were retrieved. The trends of the procedures were analysed.

Results

There were 1,460 RA patients aged ≥18 who underwent elective AASF between 2000 and 2009. During the last decade, the incidence of elective AASF in RA patients remained stable. The overall in-hospital complication rate of AASF in RA patients was 10.9%, which was more than twice that of THA and TKA in RA patients (THA: 4.8%; TKA: 4.9%). Respiratory complication rate (5.3%) was the highest among the complications. In-hospital mortality rate of such patients was 1.1%.

Conclusion

During the last decade, the incidence of elective AASF in RA patients remained stable. In-hospital morbidity and mortality rates of AASF in RA patients were higher than those of other major orthopaedic surgeries in RA patients. Respiratory management is particularly important after AASF in RA patients.

Key words

rheumatoid arthritis, atlantoaxial subluxation, surgery, atlantoaxial spinal fusion, complication, mortality, Nationwide Inpatient Sample

Hiroyuki Yoshihara, MD, PhD
Daisuke Yoneoka, MS
Adam Margalit, BS

Please address correspondence to:
Hiroyuki Yoshihara, MD, PhD,
Department of Orthopaedic Surgery
SUNY Downstate Medical Center,
450 Clarkson Ave.,
Brooklyn, NY 11203, USA.
E-mail: hiroyoshihara55@yahoo.co.jp

Received on January 29, 2016; accepted in revised form on May 26, 2016.

© Copyright Clinical and Experimental Rheumatology 2016.

Competing interests: none declared.

Introduction

Atlantoaxial subluxation (AAS) is the most frequent cervical spinal disorder in rheumatoid arthritis (RA), having been observed in 19%–70% of patients in various studies (1). AAS results from laxity of the primary and secondary ligamentous restraints (2). Severe subluxation may cause compression of the brain stem or spinal cord leading to myelopathy and, in the worst cases, even sudden death or quadriplegia (3-6). Therefore, certain RA patients with AAS undergo atlantoaxial spinal fusion (AASF) in order to prevent these irreversible neurologic deficits and avoid sudden death.

Although AASF in RA patients is a well-known procedure, RA patients undergoing AASF are not large in number. In fact, to our knowledge, there is only one study, which reported more than 100 such cases. Ohya *et al*. (7) examined in-hospital postoperative major complications and mortality in 465 RA patients undergoing AASF for AAS using the Japanese Diagnosis Procedure Combination database. Thus, information regarding AASF in RA patients is still limited.

The purpose of this study is to provide detailed demographic and outcome trend analysis of elective AASF in RA patients, using population-based national hospital discharge data collected from the Nationwide Inpatient Sample (NIS) during the last decade. In this report, the data on AASF in RA patients were compared with those on total hip arthroplasty (THA) and total knee arthroplasty (TKA) in RA patients, which are other major orthopaedic surgeries in RA patients.

Methods

Data source

The NIS is the largest all-payer inpatient care database in the US and contains data from approximately 8 million hospital stays from 1,000 hospitals each year. These data comprise a 20% stratified sample of all US community hospitals (8). Each entry in the database represents a single hospitalisation record. Records in the NIS database include discharge and hospital information, which was used to generate national estimates in this analysis. The Nationwide Inpatient Sample is publicly available and contains no personal identifying information; therefore, this study was exempt from institutional review board approval.

Patient selection

Our study samples were retrospectively obtained from the NIS between 2000 and 2009, using codes from the International Classification of Diseases, 9th revision, Clinical Modification (ICD-9-CM). Patients aged ≥18 who had a diagnosis of RA (714.0, 714.1, 714.2) and underwent AASF (81.01) were included in this study. Patients aged ≥18 who had a diagnosis of RA (714.0, 714.1, 714.2) and underwent primary THA (81.51), and primary TKA (81.54) were also extracted to compare with RA patients who underwent AASF. Only patients undergoing elective admission (inpatient admission type code 3) were included in this study in order to exclude confounding cases such as fractures.

Patient- and healthcare system-related characteristics and patient outcomes

Patient age, gender, race, comorbidities, hospital size, hospital teaching status, hospital region, payer information, complications, mortality, and disposition of patients were extracted from the NIS. Patients were categorised into the following four groups according to age: "18–44 years," "45–64 years," "65–84 years," and "older than 84 years." Patients were also categorised according to race as "white," "black," "Hispanic," "others," and "not stated." Comorbidity was assessed using the Elixhauser method, which is a well-established technique for identifying comorbidities from administrative databases (9). Elixhauser comorbidity index includes a set of 30 medical comorbidities. Total comorbidity score was determined for each case by adding 1 point per comorbidity. Hospital size (bed number) was categorised into "small," "medium," and "large", while hospital teaching status was categorised into "nonteaching" and "teaching." Hospital census region was categorised into "Northeast," "Midwest," "South," and "West", and the payer information was categorised into "Medicare," "Medicaid," "private," and "others." In-hospital complications were obtained using the following ICD-9-CM codes: neurologic complications (997.00–997.09); respiratory complications (518.4, 518.5 518.81–518.84, 997.3); cardiac complications (410, 997.1); gastrointestinal complications (535.0, 570, 575.0, 577.0, 997.4); urinary and renal complications (584, 997.5); pulmonary embolism (415.1); wound-related complications including infection, dehiscence, seroma, and haematoma (998.1, 998.3, 998.5, 998.83, 999.3). 4-digit and 5-digit codes were included under the respective 3-digit and 4-digit codes. Disposition of patients was categorised into "routine," "transfer to short-term hospital," "other transfers," "home health care," "died in hospital," and "other." Other transfers include skilled nursing facility, intermediate care, or another type of facility.

Data analysis

To calculate national estimates using the NIS, discharge weights supplied by the Federal Agency for Healthcare Research and Quality (AHRQ) were applied. Categorical patient data were retrieved. We obtained the US population data between 2000 and 2009 from the US Census Bureau Web site (10). A linear regression model was applied to analyse the time trend. The *t*-test was used to compare the means of continuous variables between the 2 groups. Characteristics between the 2 groups were assessed using χ^2 tests for equality of proportion or Fisher's exact test. Statistical analyses were performed with R v. 2.15.1 (Free Software Foundation's GNU General Public License). Because of the large sample size, a *p*-value of 0.001 was used to define significant differences.

Table I. Patient demographics and hospital characteristics of RA patients ≥18 who underwent elective AASF, THA, and TKA in the United States between 2000 and 2009.

	AASF		THA		TKA	
Total number of cases	1460		50689		121349	
Mean age (yr) (SD)	63.2 (12.0)		63.4 (13.1)		64.3 (11.2)	
	WF	%	WF	%	WF	%
Age						
18-44	108	7.4	4345	8.6	5506	4.5
45-64	693	47.5	20550	40.5	53370	44.0
65-84	645	44.2	24630	48.6	60398	49.8
≥85	15	1.0	1164	2.3	2075	1.7
Gender						
Male	309	21.2	12620	24.9	26144	21.5
Female	1151	78.8	38069	75.1	95200	78.5
Race						
White	821	56.2	29919	59.0	70710	58.3
Black	113	7.7	3331	6.6	8976	7.4
Hispanic	84	5.8	2085	4.1	4841	4.0
Others	52	3.6	1125	2.2	3154	2.6
Not stated	638	43.7	14229	28.1	33668	27.7
Elixhauser Comorbidity Score						
0	366	25.1	11422	22.5	21402	17.6
1	487	33.4	16153	31.9	37581	31.0
2	366	25.1	12820	25.3	32057	26.4
3	161	11.0	6538	12.9	18660	15.4
4 or more	79	5.4	3756	7.4	11649	9.6
Hospital size						
Small	144	9.9	6500	12.8	17032	14.0
Medium	310	21.2	12240	24.1	29878	24.6
Large	1005	68.8	31838	62.8	74033	61.0
No information	1	0.1	111	0.2	406	0.3
Hospital teaching status						
Non-teaching	328	22.5	24742	48.8	65546	54.0
Teaching	1134	77.7	25837	51.0	55397	45.7
No information	0	0.0	110	0.2	406	0.3
Hospital region						
Northeast	291	19.9	11329	22.4	23097	19.0
Midwest	343	23.5	14220	28.1	35474	29.2
South	572	39.2	19353	38.2	49822	41.1
West	254	17.4	5787	11.4	12955	10.7
Payer information						
Medicare	864	59.2	29015	57.2	70151	57.8
Medicaid	58	4.0	2415	4.8	4948	4.1
Private	471	32.3	17793	35.1	42751	35.2
Others	66	4.5	1397	2.8	3338	2.8

RA: rheumatoid arthritis; AASF: atlantoaxial spinal fusion; THA: total hip arthroplasty; TKA: total knee arthroplasty; yr : year; SD: standard deviation; WF: weighted frequency.

Results

From 2000 to 2009, a total of 1,460 hospitalisations associated with RA patients aged ≥18 undergoing elective AASF were recorded. Table I provides detailed information on patient and health care system-related characteristics of RA patients undergoing elective AASF, THA, and TKA. During that period, the incidence per 100,000 was 0.05 for AASF, 1.72 for THA, and 4.10 for TKA. The average age was 63.2 years for AASF, 63.4 years for THA, and 64.3 years for TKA. There was no clinical difference in comorbidities between RA patients undergoing AASF and THA (Elixhauser score: 2.44 *vs.* 2.54, *p*=0.004), while patients undergoing AASF had fewer comorbidities compared to those undergoing TKA (Elixhauser score: 2.44 *vs.* 2.72, *p*<0.001). The procedure was performed in teaching hospitals at a rate of 77.7% for AASF, 51.0% for THA, and 45.7% for TKA.

The number of RA patients who underwent AASF remained stable over time, from 138 in 2000 to 133 in 2009 (*p*=0.690, Table II). The population growth–adjusted rate also remained stable over time, from 0.049 per 100,000 in 2000 to 0.043 per 100,000 in 2009 (*p*=0.309, Table II).

The in-hospital complication rates of RA patients undergoing AASF was 0.0% for neurological, 5.3% for respiratory, 2.1% for cardiac, 0.7% for

Table II. Number and population-adjusted incidence of RA patients ≥18 who underwent elective AASF in the United States between 2000 and 2009.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	*p*-value
Total number of cases	138	164	129	176	147	122	155	137	158	133	0.690
Per 100,000	0.049	0.058	0.045	0.061	0.050	0.041	0.052	0.045	0.052	0.043	0.309

RA: rheumatoid arthritis; AASF: atlantoaxial spinal fusion.

Table III. In-hospital outcomes of RA patients ≥18 who underwent elective AASF, THA, and TKA in the United States between 2000 and 2009.

	AASF		THA		TKA	
Mean length of stay (SD)	5.0 (4.7)		3.9 (1.9)		3.8 (1.7)	
	WF	%	WF	%	WF	%
Complications						
Neurologic	0	0.0	44	0.1	45	0.0
Respiratory	78	5.3	387	0.8	1126	0.9
Cardiac	31	2.1	387	0.8	1111	0.9
Gastrointestinal	10	0.7	310	0.6	566	0.5
Urinary and renal	10	0.7	551	1.1	1198	1.0
Pulmonary embolism	10	0.7	87	0.2	443	0.4
Wound-related complications	20	1.4	688	1.4	1471	1.2
Overall complications	159	10.9	2454	4.8	5960	4.9
Disposition status						
Routine	801	54.9	10761	21.2	27410	22.6
Transfer to short-term hospital	29	2.0	444	0.9	1081	0.9
Other transfers	383	26.2	24496	48.3	54507	44.9
Home health care	232	15.9	14712	29.0	37676	31.0
Died in hospital	16	1.1	27	0.1	91	0.1
Other	1	0.1	10	0.0	25	0.0

RA: rheumatoid arthritis; AASF: atlantoaxial spinal fusion; THA: total hip arthroplasty; TKA: total knee arthroplasty; yr: year; SD: standard deviation; WF: weighted frequency

gastrointestinal, 0.7% for urinary and renal, 0.7% for pulmonary embolism, 1.4% for wound-related, and 10.9% for overall complications (Table III). The overall in-hospital complication rate of AASF was more than twice that of THA and TKA (THA: 4.8%, TKA: 4.9%) (AASF *vs*. THA, AASF *vs*. TKA, $p<0.001$, respectively). The in-hospital mortality rate was 1.1% for AASF, 0.1% for THA, and 0.1% for TKA (AASF *vs*. THA, AASF *vs*. TKA, $p<0.001$, respectively).

The mean length of hospital stay was 5.0 days for AASF, 3.9 days for THA, and 3.8 days for TKA (Table III). The proportion of patients who were routinely discharged was 54.9% for AASF, 21.2% for THA, and 22.6% for TKA.

Discussion

This study revealed that the incidence of elective AASF in RA patients remained stable during the last decade, although drug treatment for RA has improved markedly. The diversity of therapeutic approaches has increased, with a wide range of options for effective treatment of individual patients (11). Several randomised controlled trials have shown that treatment with disease-modifying anti-rheumatic drugs (DMARDs), corticosteroids, and biological agents early in the course of the disease can retard progression of the disease, reduce joint destruction, and improve functional ability and health-related quality of life (12). In addition, several studies have demonstrated declining trends of orthopedic surgery (13-15) and decreased prevalence of cervical involvement in patients with RA (1, 16, 17). Recently, Stein *et al*. (18) reported that the incidence of AASF in RA patients significantly decreased from 1992 to 2008 using the NIS database, although they included non-elective cases such as trauma. In contrast, our study revealed that the incidence of elective AASF in RA patients remained stable between 2000 and 2009, and biologics, the newest class of RA drugs, have been used since 1998. Thus, even though conventional DMARDs may have been shown to decrease the incidence of AASF in RA patients (18), our results may suggest that the advent of biologics was not likely to further decrease the incidence of AASF in RA patients. On the other hand, recent studies have shown low rates of RA patients being treated with biologics (19-21). In accordance with this, patients in this study population may have a low prevalence of biological DMARD use.

This study found that the incidence of AASF was 0.05 per 100,000 and was much lower than that of THA and TKA, respectively. AAS is the most frequent cervical spinal disorder in RA, having been observed in 19%–70% of patients in various studies (1). In addition, previous studies reported 35%–61% prevalence of cervical spinal instability in RA patients who had undergone THA or TKA (22-25). Thus, although a high percentage of RA patients undergoing THA or TKA may be diagnosed with AAS, most patients do not undergo AASF. The possible reasons for this include the limited number of symptomatic RA patients arising from AAS and the technically demanding surgery of AASF. Our results may also indicate that symptomatic RA patients with AAS are not common.

van Eijk *et al*. (26) reported that RA patients with cervical spine involvement tend to have more severe disease than those in whom the cervical spine was not affected. However, this study showed the mean Elixhauser comorbidity score was similar between RA patients undergoing AASF and THA, and was significantly lower in RA patients undergoing AASF compared to those undergoing TKA ($p<0.001$). This result may suggest that RA patients with an adequate overall health status were selectively chosen to undergo AASF.

The overall in-hospital complication rate of AASF in RA patients in our study was 10.9%. Ohya *et al*. (7) examined in-hospital postoperative major complications in RA patients undergoing AASF using the Japanese Diagnosis Procedure Combination database and reported that 6.5% of RA patients had at least 1 major complication. It is difficult to compare the two studies because the criteria for complications are different. Interestingly, the highest rate complication was respiratory complication (5.3%) in our study and, in contrast, it was surgical-site infection (3.2%) in their study. We do not have a clear explanation for this. However, based on our results, postoperative respiratory management is particularly important in the US population. The in-hospital mortality rate of our study was 1.1%. Ohya *et al*. (7) reported a similar rate of 0.9%.

Despite these relatively high morbidity and mortality rates, the benefits offered by AASF may delay the unfavorable course of cervical myelopathy in RA patients (27, 28). Matsunaga *et al*. (29) compared the survival rates for RA patients with symptomatic AAS undergoing laminectomy and occiptocervical fusion to those managed conservatively. None of the 21 patients managed conservatively lived past eight years while the 5- and 10-year survival rates for the 19 patients who underwent surgery were 84% and 37%, respectively. Wolfs *et al*. (28) performed a systematic review of neurologic outcomes of surgical and conservative treatments of AAS in RA patients and demonstrated that outcomes were better in operative cases compared to conservative treatment in patients with prior neurologic deficits.

In this study, we can compare in-hospital outcomes of AASF, THA, and TKA, which are three major orthopaedic surgeries for RA patients. The overall in-hospital complication and mortality rates of AASF in RA patients were more than two times and more than 10 times higher than that of THA and TKA in RA patients, respectively. RA patients need to know this increased risk when undergoing AASF. This difference in complications is mainly due to the respiratory complication rate. This fact also emphasises the importance of respiratory care after AASF. Interestingly, 77.7% of AASF, 51.0% of THA, and 45.7% of TKA were performed in teaching hospitals. This may suggest that AASF requires specialised settings. Mean length of hospital stay of AASF was about one day longer than that of THA and TKA; however, the proportion of patients who were routinely discharged was 54.9% for AASF, 21.2% for THA, and 22.6% for TKA. Thus, RA patients following AASF are physically more stable compared to those following THA and TKA. This difference may be due to the fact that patients undergoing AASF have no lower extremity surgery, which may hamper mobilisation.

Our study is limited by several factors inherent to a retrospective analysis of a large administrative database. Data entry may be subject to an element of coding or reporting bias; however, reporting should not vary substantially over time within the database. The accuracy of RA diagnoses within administrative databases has been controversial. The severity of AAS is not recorded in the database. Our data are limited to in-hospital events and the adverse events may be underestimating the true incidence. Additionally, we were unable to report the percentage of patients treated with biologic response modifiers or DMARD therapy. Despite these limitations, this study includes a large number of cases of RA patients undergoing AASF surgery and we believe that the presented data give valuable information on demographic and in-hospital outcome trends associated with elective AASF in RA patients in the US during the last decade.

Conclusion

In this study, the incidence of elective AASF in RA patients remained stable during the last decade. In-hospital morbidity and mortality rates of AASF in RA patients were higher than those of other major orthopaedic surgeries in RA patients. Respiratory management is particularly important after AASF in RA patients.

References

1. HALLA JT, HARDIN JG, VITEK J, ALARCON GS: Involvement of the cervical spine in rheumatoid arthritis. *Arthritis Rheum* 1989; 32: 652-9.
2. WASSERMAN BR, MOSKOVICH R, RAZI AE: Rheumatoid arthritis of the cervical spine--clinical considerations. *Bull NYU Hosp for Jt Dis* 2011; 69: 136-48.
3. NAKANO KK, SCHOENE WC, BAKER RA, DAWSON DM: The cervical myelopathy associated with rheumatoid arthritis: analysis of patients, with 2 postmortem cases. *Ann Neurol* 1978; 3: 144-51.
4. MATHEWS JA: Wasting of the small hand muscles in upper and mid-cervical cord lesions. *QJM* 1998; 91: 691-700.
5. CASEY AT, CROCKARD HA, BLAND JM, STEVENS J, MOSKOVICH R, RANSFORD AO: Surgery on the rheumatoid cervical spine for the non-ambulant myelopathic patient-too much, too late? *Lancet* 1996; 347: 1004-7.
6. MIKULOWSKI P, WOLLHEIM FA, ROTMIL P, OLSEN I: Sudden death in rheumatoid arthritis with atlanto-axial dislocation. *Acta Med Scand* 1975; 198: 445-51.
7. OHYA J, CHIKUDA H, KATO S *et al*.: Risks of in-hospital death and complications after fusion surgery in patients with atlantoaxial subluxation: analysis of 1090 patients using the Japanese Diagnosis Procedure Combination database. *World Neurosurg* 2015; 83: 603-7.
8. HCUP DATABASES: Healthcare Cost and Utilization Project (HCUP). 2000-2009. Agency for Healthcare Research and Quality. Rockville, MD. http://www.hcup-us.ahrq.gov/databases.jsp.
9. ELIXHAUSER A, STEINER C, HARRIS DR, COFFEY RM: Comorbidity measures for use with administrative data. *Med Care* 1998; 36: 8-27.
10. U.S. CENSUS BUREAU: Population estimates: 2000s. Available at: http://www.census.gov/popest/data/historical/2000s/index.html. Accessed June 1st, 2015.
11. MOTTRAM PL: Past, present and future drug treatment for rheumatoid arthritis and systemic lupus erythematosus. *Immunol Cell Biol* 2003; 81: 350-3.
12. KLARENBEEK NB, KERSTENS PJ, HUIZINGA TW, DIJKMANS BA, ALLAART CF: Recent advances in the management of rheumatoid arthritis. *BMJ* 2010; 341: c6942.
13. DA SILVA E, DORAN MF, CROWSON CS, O'FALLON WM, MATTESON EL: Declining use of orthopedic surgery in patients with rheumatoid arthritis? Results of a long-term, population-based assessment. *Arthritis Rheum* 2003; 49: 216-20.
14. WEISS RJ, STARK A, WICK MC, EHLIN A, PALMBLAD K, WRETENBERG P: Orthopaedic surgery of the lower limbs in 49,802 rheumatoid arthritis patients: results from the Swedish National Inpatient Registry during 1987 to 2001. *Ann Rheum Dis* 2006; 65: 335-41.
15. HEKMAT K, JACOBSSON L, NILSSON JA *et al*.: Decrease in the incidence of total hip arthroplasties in patients with rheumatoid arthritis--results from a well defined population in south Sweden. *Arthritis Res Ther* 2011; 13: R67.

16. NEVA MH, KAUPPI MJ, KAUTIAINEN H *et al*.: Combination drug therapy retards the development of rheumatoid atlantoaxial subluxations. *Arthritis Rheum* 2000; 43: 2397-401.
17. WINFIELD J, COOKE D, BROOK AS, CORBETT M: A prospective study of the radiological changes in the cervical spine in early rheumatoid disease. *Ann Rheum Dis* 1981; 40: 109-14.
18. STEIN BE, HASSANZADEH H, JAIN A, LEMMA MA, COHEN DB, KEBAISH KM: Changing trends in cervical spine fusions in patients with rheumatoid arthritis. *Spine* 2014; 39: 1178-82.
19. HAGENOW A, SEIFERT J, ZEISSIG A, CONRAD K, KLEYMANN A, ARINGER M: Relevant incidence of cervical arthritis in patients with erosive seropositive rheumatoid arthritis even today. *Clin Exp Rheumatol* 2013; 31: 213-8.
20. HETLAND ML, JENSEN DV, KROGH NS: Monitoring patients with rheumatoid arthritis in routine care: experiences from a treat-to-target strategy using the DANBIO registry. *Clin Exp Rheumatol* 2014; 32 (Suppl. 85): S141-6.
21. NAIR SC, WELSING PM, JACOBS JW *et al*.: Economic evaluation of a tight-control treatment strategy using an imaging device (handscan) for monitoring joint inflammation in early rheumatoid arthritis. *Clin Exp Rheumatol* 2015; 33: 831-8.
22. COLLINS DN, BARNES CL, FITZRANDOLPH RL: Cervical spine instability in rheumatoid patients having total hip or knee arthroplasty. *Clin Orthop Relat Res* 1991; (272): 127-35.
23. KAUPPI M, SAKAGUCHI M, KONTTINEN YT, HAMALAINEN M: A new method of screening for vertical atlantoaxial dislocation. *J Rheumatol* 1990; 17: 167-72.
24. GRAUER JN, TINGSTAD EM, RAND N, CHRISTIE MJ, HILIBRAND AS: Predictors of paralysis in the rheumatoid cervical spine in patients undergoing total joint arthroplasty. *J Bone Joint Surg Am* 2004; 86-A: 1420-4.
25. NEVA MH, HAKKINEN A, MAKINEN H, HANNONEN P, KAUPPI M, SOKKA T: High prevalence of asymptomatic cervical spine subluxation in patients with rheumatoid arthritis waiting for orthopaedic surgery. *Ann Rheum Dis* 2006; 65: 884-8.
26. VAN EIJK IC, NIELEN MM, VAN SOESBERGEN RM *et al*.: Cervical spine involvement is rare in early arthritis. *Ann Rheum Dis* 2006; 65: 973-4.
27. SCHMITT-SODY M, KIRCHHOFF C, BUHMANN S *et al*.: Timing of cervical spine stabilisation and outcome in patients with rheumatoid arthritis. *Int Orthop* 2008; 32: 511-6.
28. WOLFS JF, KLOPPENBURG M, FEHLINGS MG, VAN TUDLER MW, BOERS M, PEUL WC: Neurologic outcome of surgical and conservative treatment of rheumatoid cervical spine subluxation: a systematic review. *Arthritis Rheum* 2009; 61: 1743-52.
29. MATSUNAGA S, SAKOU T, ONISHI T *et al*.: Prognosis of patients with upper cervical lesions caused by rheumatoid arthritis: comparison of occipitocervical fusion between c1 laminectomy and nonsurgical management. *Spine* 2003; 28: 1581-7; discussion 7.