Original Article

The effect of interventions on appropriate use of lumbar spine radiograph and CT examinations in young adults and children: a three-year follow-up

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Abstract

Background: According to international guidelines, radiological examinations of the lumbar spine are of limited value and do not improve clinical outcome unless there are clinical red flags present suggesting serious pathology. Nevertheless, the utilization of lumbar spine imaging remains high.

Purpose: To follow up the effects of active referral guideline implementation and education on the number and appropriateness of lumbar spine radiographs and computed tomography (CT) examinations in young patients and to evaluate whether the appropriate radiographs have more significant findings.

Material and Methods: Referral guidelines for spine examinations and info pocket cards on radiation protection were distributed to referring practitioners. Educational lectures were provided annually. The number of lumbar spine radiographs and CT examinations on patients aged <35 years was analyzed before and three years after the interventions. Appropriateness and findings of 313 radiographs and appropriateness of 117 CT scans of the lumbar spine were assessed.

Results: The number of lumbar spine radiographs and CT scans decreased significantly after the interventions and the level remained unchanged during the follow-up (−33% and −72%, respectively, $P < 0.001$). Appropriateness improved significantly in radiographs from 2005 to 2009 (65% vs. 85%) and in CT scans already from 2005 to 2007 (23% vs. 63%). Radiographs that were in accordance with the guidelines had more significant findings compared to radiographs that were not; in young adults, this was 56% versus 21% ($P < 0.001$).

Conclusion: A combination of interventions can achieve a sustained reduction in the number of lumbar spine examinations and improve appropriateness. Inappropriate lumbar spine radiographs do not seem to contain significant findings that would affect patient care.

Keywords
Back pain, guideline, spine, radiology

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Introduction

In the Global Burden of Disease Study, low back and neck pain was the fourth leading cause of disability-adjusted life years (DALY) (1). Only ischemic heart diseases, cerebrovascular diseases, and lower respiratory infections caused more DALYs (1). The estimates of global lifetime prevalence of low back pain are in the range of 40%–70% (2,3).

Diagnostic imaging, when used appropriately, has an important role in the management of patients with

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back complaints. However, according to international guidelines, radiological examinations of the spine, especially radiographs, are of limited value and do not improve clinical outcome unless there are clinical red flags present suggesting serious pathology (4,5). Most spine imaging findings, including mild degeneration or postural abnormalities, are common in asymptomatic adults and are only weakly associated with back pain (6). When advanced imaging of the lumbar spine is required, magnetic resonance imaging (MRI) instead of computed tomography (CT) is typically recommended (5).

The radiation dose of lumbar spine radiography is among the highest for conventional radiographs and that of lumbar spine CT is about six times higher. In these examinations, radiation is also delivered to radiation-sensitive organs (5,7). When using examinations that utilize ionizing radiation, the principle of justification must always be considered due to the possibility of radiation-promoted carcinogenesis (8,9). Although the risk to a single individual is small, increased doses may result in long-term public health problems. In particular, radiation-induced lifetime risk of cancer mortality is higher at a younger age until the age of approximately 35 years, being highest in children (9,10).

It has been shown that approximately 20%–60% of all radiological examinations are inappropriate; when it comes to lumbar spine imaging, the figure is often even higher (11–17). There are various interventions designed to improve guideline implementation and enhance appropriate use of radiological examinations. A change in diagnostic practices is considered possible when well-focused, combined interventions are used (18,19).

Our previous survey regarding lumbar spine CT scans on young patients in a university hospital and an internal audit regarding the use of lumbar spine radiographs revealed inadequate justification (20). This prompted us to carry out different interventions. The aim of this study was to follow up the effects of active guideline implementation and education of professionals on the volume and appropriateness of lumbar spine CT and radiography examinations on patients aged <35 years. We assessed the number and appropriateness of examinations, but also the findings of the radiographs obtained before the interventions and during three years of follow-up.

Material and Methods

This retrospective study was performed in the Department of Diagnostic Radiology of Oulu University Hospital, Finland. The study population was selected to consist of patients aged <35 years who had had lumbar spine radiography or CT in 2005, 2007, 2008, or 2009.

Interventions

After the survey showing poor justification, various interventions were implemented in 2006 (21). The referral criteria for imaging recommended by the European Commission (EU) was available online. The printed version of the guidelines was distributed to the radiology department. Indications for spine radiographs based on these criteria were provided by email to referring practitioners and radiologists. An institutional recommendation to prefer MRI instead of CT for the lumbar spine except in the case of trauma was released.

Info pocket cards on radiation protection were provided in 2006 and updated in 2008 (21). They consisted of information on radiation, justification, and doses of different examinations including lumbar spine examinations.

Four different 3-h educational lectures were provided each year to the staff of the radiology department and referring practitioners. The sessions were also repeated; hence, altogether eight sessions were provided annually. The lectures were given by experts in radiology and consisted of legislation on radiation protection, justification, the risks and doses of radiation, indications of different radiological examinations, and specific topics, such as orthopedic and pediatric imaging. These sessions were part of official education, but attendance was voluntary. In 2006, the MRI capacity in the hospital was increased from two MRI systems to three MRI systems.

Analysis

The total volume of radiographs and CT scans of the lumbar spine performed on patients aged <35 years (0–34 years) and, separately, a detailed survey regarding children (aged 0–15 years) in 2005 and in 2007, 2008, and 2009 after the interventions were assessed. For reference, the volume of the same examinations in 2003, 2004, and, for long-term follow-up, in 2018 was also evaluated.

Most of the radiographs on children were performed in one radiological unit, whereas radiographs on young adults (aged 16–34 years) were performed in three different radiological units (units 1–3). The number of lumbar spine radiographs performed on young adults each year in each unit were analyzed. It was known that referring clinics differed between the units. Hence, we wanted to find out whether the impact of the interventions differed between the units. The proportions of the referring clinics in each unit were also analyzed.

A retrospective analysis of both appropriateness and findings concerning radiographs of the lumbar spine done in the study period was performed. The radiographs of young adults from the three radiological units were analyzed separately, as were the radiographs of children. Furthermore, the appropriateness of lumbar spine CT scans done on patients aged 0–34 years in the study period was assessed. The results concerning CT scans in 2005 and 2009 have been published before (21). Radiographs and CT scans were consecutively extracted from the electronic patient files starting from the beginning of each year. The analysis of appropriateness included 313 radiographs and 117 CT scans of the lumbar spine.

To assess appropriateness of the examinations, the referrals and corresponding patient files were analyzed by an experienced radiologist. Another radiologist analyzed the collected information to provide a second opinion. If necessary, consensus was used. The EU referral criteria including pediatric guidelines were used as a reference (5).

The analysis of the findings of the lumbar spine radiographs was based on the radiology reports. Twenty-four radiographs had no reports. Eighteen of these were follow-up examinations of a fracture or an operation with consequent significant findings. Six radiographs were later analyzed by a radiologist. Findings were categorized as significant (i.e. findings that usually affect patient care) or non-significant. Mild degeneration or mild scoliosis was not considered a significant finding.

Statistical methods

Frequency distributions and cross-tabulations were used to describe the data. The population proportions of the examinations were compared between different years using a z test for two proportions separately for lumbar spine radiographs and CT scans. A z statistic was calculated based on the number of examinations and the total population size; the data are presented as number of examinations per 100,000 persons. The proportions of justified examinations were compared between different years and units using Pearson's chi-square test. $P < 0.05$ was considered as significant. IBM SPSS Statistics v22 (IBM Corp., Armonk, NY, USA) was used to conduct the statistical analyses.

Results

Lumbar spine radiographs

In total, 1342 lumbar spine radiographs were performed on patients aged <35 years during the study period. In all, 52% of the patients were male and 48% were female. Of the study population, 27% were children. The average age of the patients in the entire study group was 21 years and that of the children was nine years. The number of lumbar spine radiographs was significantly higher in 2005 (n = 453) compared to the other years (303 in 2007, 302 in 2008, and 284 in 2009) (Table 1). The changes in the number of lumbar spine examinations in the years preceding the interventions were not significant.

The proportions of the main referring clinics for lumbar spine radiographs in different radiological units are shown in Table 2. The number of radiographs decreased in all the units. The decrease was more prominent in units 2 and 3, which received patients from non-trauma clinics (Table 2).

There was a significant difference regarding appropriateness of lumbar spine radiographs between the units, especially in 2005 ($P < 0.001$) and in 2007 ($P < 0.001$) (Table 3). The proportion of appropriate lumbar spine radiographs in 2005 was lowest in unit 3, but appropriateness improved significantly during the study period ($P = 0.001$). As unit 1 received referrals from the emergency department, the cohort from unit 1 included three children. These examinations were in accordance with the guidelines. All other patients in this appropriateness cohort were young adults (aged 16–34 years). Overall appropriateness in the units

Table 1. The numbers of lumbar spine radiographs and CT scans per 100,000 per year in patients aged <35 years (0–34 years) and in children (0–15 years) and the change in the numbers.

	2003	2004	2005	2007	2008	2009	2018	Change from 2005 to 2007		Change from 2005 to 2009	
	n/100,000							%	*P*	%	*P*
Radiographs											
<35 years	143.83	134.67	141.68	94.97	94.47	88.71	75.88	–32.97	<0.001	–37.39	<0.001
Children	70.02	71.75	66.75	65.54	55.61	58.46	46.79	–1.81	0.898	–12.42	0.369
CT scans											
<35 years	59.59	68.43	41.28	11.60	11.89	8.43	8.83	–71.9	<0.001	–79.58	<0.001
Children	2.00	3.35	1.35	2.05	1.37	4.81	0.71	51.85	0.645	256.3	0.090

Table 2. The proportions of the main referring clinics for lumbar spine radiographs done on young adults in different units during the study period and the change in the number of radiographs.

	Unit 1	Unit 2	Unit 3
Main referring clinics (%)	Emergency department (49) Surgery and neurosurgery (49)	Physical medicine (47) Internal medicine (37) Other non-trauma clinics: gynecology, neurology, and oncology (7)	Student healthcare (54) Occupational healthcare (18) Primary healthcare (13) Surgery (non-acute patients) (11)
Change in number of radiographs (%)			
2005–2007	–21	–63	–79
2005–2009	–32	–82	–45

Table 3. The proportion of appropriate lumbar spine radiographs and CT scans in patients aged <35 years and separately, radiographs in children (aged 0–15 years) in different years.

	Radiographs									
	Unit 1*†		Unit 2*		Unit 3*		Children		CT scans	
	n/total	%	n/total	%	n/total	%	n/total	%	n/total	%
Year										
2005	19/20	95	13/20	65	7/20	35	17/20	85	7/30	23
2007	16/20	80	11/20	55	8/20	40	20/20	100	19/30	63
2008	20/20	100	17/20	85	15/20	75	20/20	100	23/30	77
2009	19/20	95	10/13	77	16/20	80	20/20	100	22/27	81

The number of radiographs analyzed is 20 per unit each year (except in unit 2 in 2009, as only 13 cases were available). The number of CT scans analyzed each year is 30 (except in 2009, as only 27 cases were available).

*Main referring clinics in unit 1: emergency department, surgery and neurosurgery clinics; unit 2: physical and internal medicine clinics; unit 3: student, occupational, and primary healthcare.

†Includes three children.

improved from 65% in 2005 to 85% in 2009 ($P = 0.005$).

Indications for the inappropriate examinations in young adults were acute or prolonged back pain in 68% and symptoms of disc syndrome in 31% of the cases. Indications for appropriate examinations were trauma and suspicion of fracture (38%), follow-up of fracture or postoperative control (24%), suspicion or control of spondyloarthropathy (16%), suspicion of bone anomalies (7%), and follow-up of spondylolysis or spondylolisthesis (7%).

The total proportion of significant findings was higher in radiographs that were in accordance with the guidelines than in radiographs that were not; in young adults, this was 56% versus 21% ($P < 0.001$; Table 4). Regarding the appropriate examinations in young adults, significant findings were a fracture in 23% of the cases, control of a fracture or an operation in 40%, spondylolysis and/or spondylolisthesis in 24%, and sacroiliitis in 11%. Regarding the inappropriate examinations, the significant findings were mainly spondylolysis and/or spondylolisthesis (83%). In children, the main significant findings related to the appropriate examinations were spondylolysis and/or spondylolisthesis (50%) and a fracture or control of a fracture or an operation (29%).

Lumbar spine CT examinations

In total, 234 lumbar spine CT examinations were performed on patients aged <35 years. In all, 6% of these patients were children. The average age of the patients

Table 4. The proportion of significant findings in appropriate and inappropriate lumbar spine radiographs.

Lumbar spine radiographs with significant findings (n/total (%))								
	Appropriate examinations				Inappropriate examinations			
	Unit 1*	Unit 2*	Unit 3*	Children	Unit 1*	Unit 2*	Unit 3*	Children
2005	11/19 (58)	7/13 (54)	5/7 (71)	9/17 (53)	0/1	2/7 (29)	6/13 (46)	0/3
2007	10/16 (63)	6/11 (55)	5/8 (63)	11/20 (55)	0/4	1/9 (11)	1/12 (8)	0/0
2008	8/20 (40)	4/17 (24)	9/15 (60)	9/20 (45)	0/0	1/3 (33)	1/5 (20)	0/0
2009	10/19 (53)	5/10 (50)	16/16 (100)	8/20 (40)	0/1	0/3	1/4 (25)	0/0
Total	39/74 (53)	22/51 (43)	35/46 (76)	37/77 (48)	0/6	4/22 (18)	9/34 (26)	0/3

*Main referring clinics in unit 1: emergency department, surgery and neurosurgery clinics; unit 2: physical and internal medicine clinics; unit 3: student, occupational, and primary healthcare.

in the entire study group was 27 years and that of children, 13 years. The number of lumbar spine CT scans decreased significantly from 2005 to 2007 and the result persisted during the follow-up (Table 1).

The proportion of appropriate lumbar spine CT scans was low in 2005 compared to the other years ($P < 0.001$; Table 3). The improvement from 2005 to 2007 was already significant ($P = 0.004$) and the level remained unchanged during the follow-up. The cohort of 117 CT scans included 11 children and all of these examinations were appropriate.

Indication for inappropriate lumbar spine CT scans was back pain or symptoms of disc syndrome in 93% of the cases. Indications for justified examinations were trauma and suspicion of fracture in 59% of the cases and postoperative control in 32% of the cases.

Discussion

In the present study, a combination of interventions, guideline implementation, and education decreased the number of lumbar spine radiographs and CT scans in young patients, and the result persisted after three years of follow-up. The interventions resulted in more appropriate examinations than before. It also appears that the appropriate radiographs had more significant findings than the inappropriate ones.

The volume of lumbar spine radiographs performed on patients aged < 35 years and also on all age groups decreased significantly (> 30%) during the study period; while in Finland as a whole, the volume remained almost unchanged from 2005 to 2008 (22,23). Furthermore, the number of lumbar spine radiographs performed on young patients in our hospital in 2018 was 14% lower than in 2009. This suggests a sustained change in the practice.

In the studies concerning lumbar spine radiographs, guideline implementation with or without education has reduced the number of referrals from 20% to 80% (24–28). However, these studies did not assess appropriateness. Eccles et al. reported that guideline implementation improved radiology referrals appropriateness (29). In another study, the number of spine radiographs decreased by about 30% and appropriateness improved from 40% to 45% after implementation of targeted guidelines (12).

In the present study, the radiographs in the radiological units that had more selected patient groups—children and those referred from the emergency department or surgery clinics—were more appropriate already before the interventions. The level of appropriateness was unexpectedly low (62%) in the other units that received patients from student, occupational, or primary healthcare, for example. These patients may be more unselected and non-medical aspects, such as expectations of the patients or relatives, may have an effect on the requests. With the help of constant education, the number of radiographs in these units decreased significantly while appropriateness improved. However, there were still too many inappropriate radiographs in 2009. The use of guidelines is crucial, and their use should be easy and mandatory. Guidelines in the form of clinical decision support embedded in the electronic imaging order entry could solve the problem.

There is some earlier research showing that appropriate radiological examinations have more significant results than inappropriate examinations (11,16,30,31). The findings of the present study complement earlier research. One of the key findings is that the appropriate lumbar radiographs had significantly more often findings that usually affect patient care compared to the inappropriate ones. However, the real impact of these findings on patient care was not assessed. Regarding the inappropriate radiographs, almost all significant findings were spondylolysis and/or spondylolisthesis. According to the literature, these findings can be found in approximately 5%–10% of all adults. Although spondylolysis and spondylolisthesis are conditions that can require treatment, there are many

studies that have found no association between these conditions and low back pain (32–35). The impact of these findings in radiographs and on patient care is therefore controversial. In our study, none of these patients required surgery for this condition and the treatment, if any, was physiotherapy, which could have been carried out without any radiological examination.

In our study, the number of lumbar spine CT scans on young patients decreased significantly after the interventions and the level remained unchanged. The corresponding decrease in the volume of lumbar CT scans in all age groups in our hospital was comparable to this study, approximately 70%, while in Finland as a whole, there was a decrease of about 20% from 2005 to 2008 (23). In contrast, the total volume of CT examinations increased between 2005 and 2009 in our hospital, in Finland, and globally (23,36). The total number of MRI examinations and the number of lumbar spine MRIs increased significantly from 2005 to 2009 in our hospital (21). There was thus a quite clear change in practice during this period to use MRI instead of CT in lumbar spine imaging.

Earlier research has shown that only 50%–60% of lumbar spine CT scans are appropriate (16,17). In the study by Clarke et al., it was stated that 91% of lumbar spine CT scans should have been replaced by MRI, and in another study, 75% of pediatric lumbar spine CT scans were cancelled due to inappropriateness (37,38). In the present study, only 23% of the lumbar spine CT scans were appropriate before intervention, but there was a dramatic improvement in appropriateness after the interventions as after the follow-up 81% of the lumbar CT scans were appropriate.

The present study reveals the importance of referral guidelines and their active use. However, it is known that, in general, plain referral guidelines are not utilized efficiently unless their use is emphasized and supported. Guidelines in the form of clinical decision support tool could be of help in this problem (39–41). Studies that have assessed the impact of clinical decision support on radiological imaging has shown a decrease in the number of CT examinations and improvement in the use of guidelines in the test ordering process (42–46).

To our knowledge, there are no other studies that have concentrated both on the appropriateness and findings of lumbar spine examinations in young patients. One strength of the present study is that it focused on young patients who are more sensitive to radiation. We also had the three-year follow-up audit, which is missing from all other similar studies. Although the present study assessed the effects of interventions carried out several years ago, the interventions are still relevant. There are also recent reports of a notable proportion of inappropriate examinations, regarding, in particular, CT scans of the spine (14,15). It should also be noted that the guidelines on spine imaging have remained unchanged.

The present study has some weaknesses. First, the study was carried out in only one hospital. Therefore, targeting of the education was easier than in multicenter studies. Second, participation in the educational lectures was not monitored. Monitoring might have given an interesting perspective to the study. In addition, the impact of different interventions was not measured separately. Some interventions may have guided the practice more than others, and improved access to MRI may have had effect. Furthermore, it is not possible to know whether some patients had radiographs performed in other health care institutions.

In conclusion, a combination of interventions—guideline implementation and education—can achieve a sustained reduction in the number of lumbar spine radiographs and CT scans in young patients and improve appropriateness of the examinations performed. Furthermore, inappropriate lumbar spine radiographs performed on patients with low back complaints do not seem to have significant findings that would affect patient care. The interventions used in this study may reduce exposure to radiation and release resources for appropriate examinations.

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