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# Trends in the utilization of advanced diagnostic imaging and lumbar disc disorders diagnosis in the Warmia and Mazury Province, Poland

*Małgorzata Kolenkiewicz, Joanna Wojtkiewicz*

*Department of Pathophysiology, Faculty of Medical Sciences, University of Warmia and Mazury in Olsztyn, Poland*

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ABSTRACT

Introduction: Magnetic resonance imaging (MRI) is one the most important diagnostic techniques, and the use of MRI scanners is becoming progressively more extensive and increase annually worldwide and in Poland. MRI scans are used by neurosurgeons, orthopedists and neurologists indicating that the diseases most frequently diagnosed using MRI are related to musculoskeletal and central nervous system dysfunction.

Aim: The main aim of this study was to determine the extent of MRI scanner utilization in the University Clinical Hospital (UCH) in Olsztyn, in the years 2011–2015 and to examine data sets concerning spinal and back injuries, the age and sex of patients within the most frequently examined sub-populations.

Material and methods: Analyses were performed using the patients' digital database including 13 298 MRI reports in UCH, in years 2011–2015.

Results and discussion: The results show that the use of MRI scanner in the UCH increased over the study period. The diseases most frequently diagnosed using MRI were musculoskeletal diseases, among which the spinal diseases were most common. More women than men were enrolled in the diagnostic tests and majority of patients were in the age range of 50–61 years.

Conclusions: The number of MRI tests indicates high demand for MRI scanners in the Warmia and Mazury Province. As the intervertebral disc disorders are most common in people of working age (51–60 years), early checkups and prevention of vertebral column diseases should be implemented at younger age, by introducing examinations followed by recommendations of corrective gymnastics and/or physiotherapy when indications of pathological changes are noticed.

*Corresponding author: Małgorzata Kolenkiewicz, Department of Pathophysiology, Faculty of Medical Sciences, University of Warmia and Mazury in Olsztyn, Warszawska 30, 10-082 Olsztyn, Poland. Tel.: +4889 524 53 30, Fax: +4889 524 53 18. E-mail address: malgorzata.kolenkiewicz@uwm.edu.pl.*

## 1. INTRODUCTION

The magnetic resonance imaging (MRI) is currently one of the most advanced diagnostic imaging techniques. The use of MRI scanners has been increasing since the 1980s.[1] Although patients and radiologists-technicians are exposed to the low energy static magnetic fields during examinations, MRI scanners are safe and each year the number of MRI-diagnosed patients is increasing due to the unique features of this technology.[2] These include advanced image enhancement, and a more complete diagnosis compared to X-rays, particularly in case of changes in joints' structures or soft tissues and organs.[1,3] Since MRI provides an accurate, noninvasive evaluation, MRI tests are very often either replacing or being used in addition to traditional tests such as X-rays. The diagnostic potentials of MRI are further increased by the use of improved contrast resolution, and introduction of the high-magnetic field equipment of 1.5 T, 3 T and higher. On the other hand, the availability of MRI in hospitals worldwide is still relatively low, and there are some disadvantages of this technique, such as much longer testing time compared to computer tomography, difficulties in examining some patients, i.e. unconscious or with contraindications to MRI such as cardiac pacemakers, metallic implants in soft tissues, foreign objects in the eye or claustrophobia.[3,4]

Although MRI is already the most expensive among the new imaging techniques, the further technical developments are still ongoing because of the unique imaging abilities described above.

The use of MRI scanners has been increasing each year in many European countries, the Middle East and Asia.[4,5] In the United States, the number of MRI examinations has been increasing by about 26% per year and nearly tripled in one decade (1997–2006).[6–8]

The first MRI scanner in Poland was launched in 1991, and according to The Statistical Bulletins of The Polish Ministry of Health, the number of MRI scanners increased from 47 in 2003 to 246 in 2014, mostly in public hospitals, and in the same time period, a number of MRI laboratories increased from 46 to 143. In the reporting period, the availability rate of MRI scanners in Polish hospitals has increased from 0.12 to 0.40 for 100 000 people. In hospitals of the Warmia and Mazury Province this indicator has changed from 0.07 to 0.10.[9]

According to the Polish Central Statistical Office, in 2011 the number of MRI scanners for 1 000 000 people in Poland was one of the lowest in the world (4.8) whereas the highest was in Japan (46.9). MRI scans rate per 1000 people was the highest in the USA (102.7), whereas in Poland it was much lower (17.7).[10]

MRI is reportedly the best method of imaging of the spinal cord and its disorders, as the examination enables visualization of intervertebral discs, roots of spinal nerves, spinal cord vascularization and spinal column ligaments.[1,3] In the Middle East, neurosurgeons, orthopedists and neurologists contributed to more than 88% of MRI utilization and the spinal column was among body parts most commonly scanned by MRI machines.[4] Although traditionally low back pain occurs in about 80% of the adult human population, some reasons for the spinal column disorders are work- and sports-related, are due to the motor vehicle accidents, falls from heights, violence, diving into shallow water, genetic factors and others.[11–22]

## 2. AIM

To determine: (1) the extent of MRI scanner utilization in the University Clinical Hospital in Olsztyn in the years 2011–2015, (2) the percentage of tests concerning spinal and back injuries and (3) correlation of the spinal injuries with age and sex of patients.

## 3. MATERIAL AND METHODS

The changes in the utilization of MRI scanner Magnetom Trio A Tim System 3T in the University Clinical Hospital in Olsztyn, in the years 2011–2015 were evaluated. The digital database included 13 298 MRI reports and an information about the patients' age, sex, the time of tests, and the disease codes assigned by physicians using *International Statistical Classification of Diseases and Related Health Problems*, tenth Revision (ICD-10).[23]

The first MRI scans in the University Clinical Hospital in Olsztyn were performed at the end of 2010, but in this study scans from January 1st 2011 to December 31th 2015 were examined.

Following the analyses of the MRI scanner utilization each year, categories of diseases were examined and the most frequently diagnosed disorders were chosen for the more detailed evaluations.

This study has focused on the diseases of the musculoskeletal system and connective tissue (codes M00–M99; ICD-10), and only the diseases described with the general term 'spinal test' and including the dorsopathies such as damage of vertebral column, roots of spinal nerves and paravertebral tissue (codes M40–M51) were selected, while back diseases described by other codes were excluded. Subjected to analysis were the patients' age and sex, and proportions of the female and the male patients in each examined year. Moreover, to determine the most numerous age group, patients were subdivided into the 10 age groups in each study year.

## 4. RESULTS

### 4.1. Characteristic of the analyzed population

In this study 13 298 MRI examinations from a 5-year period have been evaluated. The average number of scans was 2659.6 per year and the number of tests gradually increased. The highest number of tests was observed in 2013 and was nearly 2.5 times higher than at the beginning of the use of MRI scanner in 2011 (Figure 1). The most frequent referrals were for musculoskeletal tests among which the most-

**Table 1. Musculoskeletal, back, and spine MRI scans in years 2011–2015.**

| Years | 2011 | 2012 | 2013 | 2014 | 2015 | 2011–2015 |
|---|---|---|---|---|---|---|
| Total number of MRI scans | 1443 (44.01%)[2] | 2340 (53.46%)[2] | 3527 (43.78%)[2] | 3139 (51.86%)[2] | 2849 (49.95%)[2] | 13298 (48.74%)[2] |
| Total of MRI scans in all musculoskeletal (M) diseases[1] | 724 (46.08%)[3] | 1414 (57.52%)[3] | 1810 (48.09%)[3] | 2001 (57.25%)[3] | 1755 (54.26%)[3] | 7711 (57.98%)[3] |
| Back and spine MRI scans | 665 | 1346 | 1696 | 1797 | 1546 | 7050 |
| Spine MRI scans | 635 | 1251 | 1544 | 1628 | 1423 | 6481 |
| Percentage of spine and back MRI tests among all M tests | 91.85 | 95.19 | 93.70 | 89.81 | 88.09 | 91.51 |
| Percentage of spine MRI tests among spine and back tests | 95.49 | 92.94 | 91.04 | 90.60 | 92.04 | 91.93 |

Comments: [1] *International Statistical Classification of Diseases and Related Health Problems*, 10th Revision (ICD-10)[23]; [2] Percentage of musculoskeletal scans among total MRI scans; [3] Percentage of spinal MRI scans among total MRI scans. Source: University Clinical Hospital in Olsztyn.

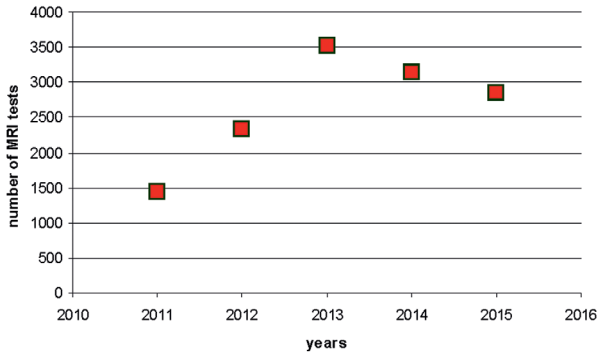


**Figure 1. The changes of utilization of MRI scanner in University Clinical Hospital in Olsztyn in 2011–2015.**

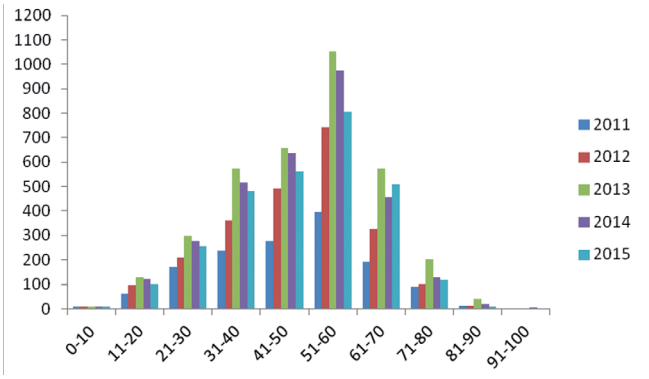


**Figure 2. The number of total MRI tested patients in 10 age ranges from 2011 to 2015. Source: University Clinical Hospital in Olsztyn.**

common were back and spine tests. They constituted about 50% of all cases per year and only small fluctuations were observed over the years. The results show that among all back and spine tests, most were related only to spine diseases (about 90%) and their number was similar during the entire period examined (Table 1).

During the whole investigated period, the average age of the male and the female patients with various diseases was similar: 47 ± 15 and 49 ± 14 years, respectively. In the spinal tests the average age of patients was higher the male 49 ± 12 and the female 51 ± 12, respectively (Table 2).

**Table 2. Mean age of patients by sex enrolled in MRI tests in 2011–2015.**

| Gender | Female | Male |
|---|---|---|
| Age: all MRI scans | 49±14 | 47±15 |
| Age: spine MRI scans | 51±11 | 49±12 |

The results show that in all MRI tests the most numerous age group was 51–60 years and the least numerous group was 90–100 years. The range of 50–61 years of age was the most numerous in each year of using MRI scanner and had slightly increased by 2013 (Figure 2). In

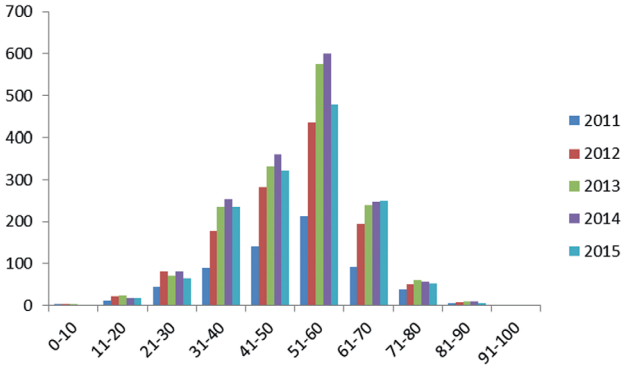


**Figure 3. The number of spinal MRI tested patients in 10 age ranges from 2011 to 2015. Source: University Clinical Hospital in Olsztyn.**

spinal MRI tests the least numerous group was 0–10 years old (patients 90–100 years old were absent), whereas the most numerous age range was 50–61 years for the whole 5-years as well as for each single year. In this group the number of patients has increased by 2014 (Figure 3). The results show that more women than men were enrolled in all MRI examinations during the 5 years. Women represented over 60% of the population both in the all MRI

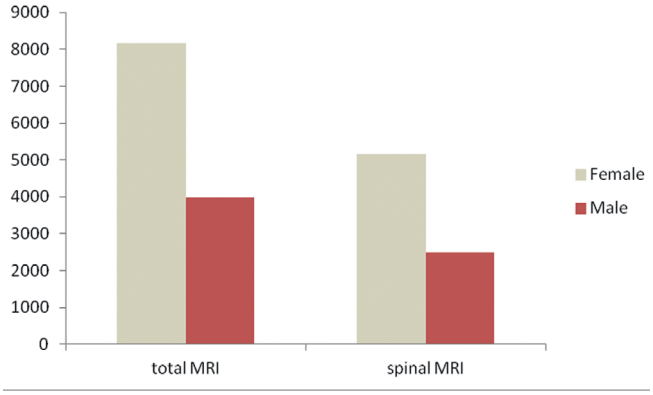


**Figure 4. Female and male patients in total MRI scans and spinal MRI scans. Source: University Clinical Hospital in Olsztyn.**

**Table 3. Percentage of female and male patients scanned in all MRI tests and spine MRI tests from 2011 to 2015.**

| | All MRI tests | | Spine MRI tests | |
|---|---|---|---|---|
| Year of tests | Female | Male | Female | Male |
| 2011 | 60.78 | 39.22 | 61.57 | 38.43 |
| 2012 | 61.54 | 38.46 | 62.51 | 37.49 |
| 2013 | 61.20 | 38.80 | 61.72 | 38.28 |
| 2014 | 61.77 | 38.23 | 61.43 | 38.57 |
| 2015 | 60.93 | 39.07 | 60.51 | 39.49 |
| 2011–2015 | 61.29 | 38.71 | 61.52 | 38.48 |

and in selected spinal tests. The same proportion was observed in the most numerous age range group of 51–60 (Figure 4; Table 3).

### 4.2. Details of analyzed diseases

The analyzed digital database provided information about presumed diseases ascribed to the patients according to ICD-10 codes. In the investigated period of time most of the diseases included in ICD-10 have been distinguished. Diseases of the musculoskeletal system and connective tissue (M category; M00-M99) were the most frequent in each year and in the whole period of time.

In the whole M category only dorsopathies (M40–M51) were selected for detailed analysis. The database provides two types of ICD-10 codes, i.e. general diseases codes such as M51 and more detailed codes e.g. M51.1. or M51.2.

Results have shown that the most frequently occurring diseases in each year and in the entire 5-year studied period were M47 (spondylosis), M50 (cervical disc disorders) and M51 (other intervertebral disc disorders). Among all spinal diseases they represented over 4%, 12% and 30%, respectively (Table 4). The subject of main interest in the presented study was the most numerous M51 group. In this group all subtypes of diseases classified in ICD-10 such as e.g. M51.0–M51.4 and M51.8–M51.9 were found. The most numerous of them were chosen for detailed analysis in the present study (Table 5).

Intervertebral disc disorders were described in 4095 cases in the entire examined time period and the vast majority was defined by a general code M51 (3262 cases). Very few of the cases had more specific codes and among those the most numerous were M51.1 (lumbar and other intervertebral disc disorders with radiculopathy) represented by 232 cases, M51.2 (other specified intervertebral disc displace-

**Table 5. Percentage of M51 category diseases among all spinal diseases 2011–2015.**

| code | number of cases | percent |
|---|---|---|
| M51 | 3262 | 79.66 |
| M51.0 | 16 | 0.39 |
| M51.1 | 232 | 5.66 |
| M51.2 | 337 | 8.23 |
| M51.3 | 212 | 5.18 |
| M51.4 | 2 | 0.05 |
| M51.8 | 31 | 0.76 |
| M51.9 | 2 | 0.05 |
| total | 4095 | 100.0 |

**Table 4. Percentage of specific M-category diseases in M category of ICD-10.**

| Percentage of disease codes [%] | 2011 | 2012 | 2013 | 2014 | 2015 | 2011–2015 |
|---|---|---|---|---|---|---|
| M40 | 0 | 0.00 | 0.00 | 0.13 | 0.07 | 0.05 |
| M41 | 0.14 | 0.04 | 0.17 | 0.16 | 0.18 | 0.14 |
| M42 | 0.16 | 0.04 | 0.03 | 0.03 | 0.00 | 0.03 |
| M43 | 0.07 | 0.09 | 0.03 | 0.03 | 0.04 | 0.05 |
| M45 | 0.00 | 0.00 | 0.00 | 0.06 | 0.11 | 0.04 |
| M46 | 0.00 | 0.04 | 0.03 | 0.00 | 0.00 | 0.02 |
| M47 | 3.81 | 3.29 | 3.74 | 5.38 | 6.14 | 4.57 |
| M48 | 0.00 | 0.00 | 0.48 | 1.34 | 0.77 | 0.61 |
| M49 | 0.14 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 |
| M50 | 10.88 | 11.11 | 13.58 | 14.40 | 10.92 | 12.48 |
| M51 | 28.90 | 38.85 | 25.72 | 30.33 | 31.73 | 30.75 |

**Table 6. Number of M51 categories diseases, 2011–2015.**

| Types of category M diseases | 2011 | 2012 | 2013 | 2014 | 2015 | 2011–2015 |
|---|---|---|---|---|---|---|
| M51 | 417 | 909 | 839 | 668 | 430 | 3263 |
| M51.1 | 0 | 0 | 44 | 110 | 78 | 232 |
| M51.2 | 0 | 0 | 3 | 91 | 236 | 330 |
| M51.3 | 0 | 0 | 3 | 64 | 145 | 212 |
| Others | 0 | 0 | 18 | 19 | 15 | 52 |
| All M51 diseases | 417 | 909 | 907 | 952 | 904 | 4089 |

ment) represented by 337 cases and M51.3 (other specified intervertebral disc degeneration) represented by 212 cases (table 6). The number of M51 cases showed an increase until 2012 and small fluctuations in the following years. The M51.1, M51.2 and M51.3 cases were observed for the first time in 2013. The number of lumbar and other intervertebral disc disorders with radiculopathy (M51.1) was increasing until 2014 and subsequently decreased in 2015, whereas the number of M51.2 and M51.3 cases was increasing between 2013 and 2015. Others diseases were detected for the first time in 2013 and their number remained similar till 2015.

## 5. DISCUSSION

### 5.1. Utility of MRI scanners

Our study shows that utilization of the MRI scanner Magnetom Trio A Tim System 3T in the University Clinical Hospital in Olsztyn gradually increased between 2011 and 2015 and that increasingly more patients have been examined. Reports from the United States have shown that from 1997 to 2005 the importance of the MRI method has increased compared to other techniques such as ultrasound or computer tomography.[6,8] Moreover, MRI utilization rate per 1000 persons has increased in 2000–2009.[8] The results also show that the most numerous age group using MRI tests was 51–60 years old, i.e. similarly to the USA where the most numerous group using MRI was over 45 years old.[6–8] Overall, more women than men were enrolled in all MRI tests in the University Clinical Hospital in Olsztyn and the same pattern was observed in the USA.[6]

The study shows that most of MRI scans were related to musculoskeletal diseases and this finding is consistent with previous data showing that the spinal column is one of the most frequently MRI-scanned parts of the body.[5]

Inspection of the literature also shows that musculoskeletal disorders (MSD) represent one of the most common and most expensive occupational health problems both in developed and developing countries. The database employed in the present study did not provide information about patient's occupations however, other studies have shown that MSD occurs in many professions and is primarily related to physical work. The work-related MSD (WRMD) has been defined as a musculoskeletal injury that results from a work-related event. Some reports have shown that the most frequent among WRMD complaints was the low back pain (26%–70%) and neck pain (12%–34%). In both, healthcare workers like physiotherapists, nurses or dentist, and hand-workers like construction workers, farmers and shipyard workers, the percentage of complaints about any of musculoskeletal disorders was similar (47%–91%).[14–22] Moreover in healthcare workers, the age, sex, years of work and workload had a huge influence on the appearance of the diseases[16–19] and musculoskeletal pain was a risk factor for long-term sickness absence in some of these professions.[16,21]

### 5.2. Intervertebral disc disorders (M51)

In the present study the intervertebral disc disorders (M51) were the most common diseases found during MRI tests. According to ICD-10 codes, this category includes thoracic, thoracolumbar and lumbosacral disc disorders. M51 was found most frequently at the age of 51–60 years with more cases in women than men. Moreover, three specify codes such as M51.1 – lumbar and other intervertebral disc disorders with radiculopathy, M51.2 – other specified intervertebral disc displacement, and M51.3 – other specified intervertebral disc degeneration were distinguished. The present data does not provide any details about location of damage or level of back pain. The code M51.1 indicates only that changes were on the lumbar level. Most cases reported in the literature describe low back pain related to lumbar and lumbosacral disc disorders[24–26] so all M51 diseases were treated as degeneration at lumbar and lumbosacral levels.

Spinal diseases are a serious social problem. The back pain can be due to various factors and in 90% of patients it is mainly caused by damage or degenerative changes in the intervertebral discs or spondyloarthrosis.[24] The lumbar disc degeneration (LDD) has a broad meaning that encompasses apparent desiccation, fibrosis, narrowing of the disc space, diffuse bulging of the annulus beyond the disc space, defects and sclerosis of the endplates, and osteophytes at the vertebral apophyses.[27,28] Moreover, LDD can be caused by many factors such age, environmental and behavioral influences or genetics.[11–13] Early degenerative changes may be undetectable in MRI image and they could be related to impaired disc metabolism, biochemical changes and many types of disc structural failures.[11]

Symptoms of back problems have been very often described by patients as low-back pain (LBP) and/or sciatica,

such as pain going down the lower limb from the back usually only on one side of the body. In the Unites States, 2% of patients complain about LBP and in 2005 the total health care expenditures related to LBP were estimated at $89 000 000.[24] The relationship between changes detected with MRI of the vertebral column and clinically-manifested changes are of general interest and it is thought that the pain at lumbar or sacral levels strongly correlates with the extent of changes observed in MRI scans.[25]

It is believed that the lumbar part of the vertebral column is less likely to be damaged during an accident than the cervical part. Some studies have shown that only 16%–14% of car accidents cause it[29,30] and that almost all changes in the lumbar part are related to disc degeneration. In Denmark, 36% of changes in the lumbar part of the vertebral column were non-traumatic.[31] In China, the occurrence of non-traumatic lumbar disc damage has doubled in 20 years.[26]

Moreover, each level of lumbar inter-vertebral discs shows a different vulnerability to injuries and diseases. Specifically, changes consequent to injuries and/or diseases are very often observed at the cartilage endplate at the L1–L3 level but are less common at the upper level of lumbar vertebrae (L1–L3).[32] Notably, very often more than one of lumbar inter-vertebral disc is affected by morphological changes.[33]

In previous studies, the most numerous changes were typically observed in the L4–L5 and L5–S1 inter-vertebral discs and the most frequently found changes were due to herniation, dehydration and decreased disc height.[25,26,33–36] All changes at lower lumbar levels appear to correlate with the age and body mass index, which are well-recognized risk factors for LDD.[32]

In Poland, lumbar changes were observed at each stage of the development.

## 6. CONCLUSIONS

The increase in the number of MRI tests indicates a high demand for MRI scanners in the Warmia and Mazury Province. The most commonly affected is the working-age population indicating the importance of early checkups and prevention of the vertebral column diseases during younger age. The intervertebral disc disorders are also likely associated with the type of profession and work.

It would therefore be valuable to add to the public health policies, a model of spinal health education and vertebral column disease prevention starting from the school age and run through the retiring age, finding problems before they start. The prevention model would include vertebral column examinations followed by recommendations of a corrective gymnastics and/or physiotherapy when early indications of existing or potential pathological changes are noticed, and it could be implemented as a routine component of a regular health exams and tests.

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