



APPLICATION OF PANORAMIC T2 SEQUENCE FOR MAGNETIC RESONANCE IMAGING OF LUMBOSACRAL SPINE

APLICACIÓN DE SECUENCIA T2 PANORÁMICA PARA RESONANCIA MAGNÉTICA DE COLUMNA LUMBOSACRA

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ABSTRACT

Introduction: The evaluation of the total spine by magnetic resonance imaging in a T2-weighted single sequence using Software Composing previous planning, called panoramic, would be beneficial in the study of lumbosacral spine for the additional information that could be obtained. **Objectives:** To analyze the application of T2 panoramic sequence for magnetic resonance imaging of the lumbosacral segment. **Method:** Retrospective and cross-sectional study executed with 186 cases selected by stratified probability sampling, between 18 and 60 years old, using a form consisted of a general sheet and an analytical sheet obtained from the request for radiological study and the examination itself. **Results:** Of the total, 80.1% were in the adult stage of life, and 53.8% were female, and 52.7% had the suspicion of herniated disc as a specific diagnostic presumption. Degenerative pathologies were mainly presented, with 93%, having herniated discs as the most frequent with 57%, which included extruded, protruded and migrated hernias with 40.6%, 37.9% and 21.5 % respectively. Likewise, it was verified with hypothesis test that this acquisition allows to localize 50% more findings in contrast to the usual examination, defining that this sequence should be applied because it localizes findings in a greater number in comparison to the lumbosacral selective examination. **Conclusions:** In general, it was defined that the application of this panoramic T2 sequence is more usefulness for a better evaluation, because it achieves greater findings, resulting as main pathologies in lumbosacral, cervical and dorsal segments those of a degenerative type, standing out the herniated discs.

Key words: Magnetic resonance imaging; Radiologic technology; Spine (source: MeSH NLM).

RESUMEN

Introducción: La evaluación de columna total mediante resonancia magnética en una sola secuencia potenciada en T2 utilizando Software Composing previa planeación, denominada panorámica, sería beneficioso en el estudio de columna lumbosacra por la información adicional que podría obtenerse. **Objetivos:** Analizar la aplicación de secuencia panorámica en T2 para resonancia magnética del segmento lumbosacro. **Métodos:** Estudio retrospectivo y transversal realizado con 186 casos seleccionados mediante muestreo probabilístico estratificado, entre 18 a 60 años, utilizándose una ficha conformada por una hoja general y una hoja analítica obtenidas de la solicitud de estudio radiológico y el propio examen realizado. **Resultados:** Del total, un 80,1% era de etapa de vida adulta, y 53,8% era femenino, además que un 52,7% tuvieron como presunción diagnóstica específica la sospecha de hernia discal. Se presentó principalmente patologías degenerativas, en un 93%, teniendo a las hernias como las más frecuentes en un 57%, que a su vez comprendió hernias extruidas, protruidas y migradas con 40,6%, 37,9% y 21,5% respectivamente. Así mismo, se comprobó con prueba de hipótesis que esta adquisición permite localizar un 50% más de hallazgos a diferencia del examen habitual, definiéndose que esta secuencia debe aplicarse porque localiza hallazgos en un mayor número en comparación al examen selectivo lumbosacro. **Conclusión:** De forma general, se definió que la aplicación de esta secuencia T2 panorámica es de mayor utilidad para una mejor evaluación, por lograrse mayores hallazgos, resultando como patologías principales tanto en segmento lumbosacro como cervical y dorsal las de tipo degenerativas, resaltando las hernias discales.

Palabras clave: Imagen por resonancia magnética; Tecnología radiológica; Columna vertebral (fuente: DeCS BIREME).

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INTRODUCTION

The Peruvian population has undergone a sociodemographic transition with a decrease in the mortality rate, a larger economically active population, and population aging, with a greater presentation of chronic-degenerative diseases to the detriment of infectious diseases⁽¹⁾. Among this group of now frequent diseases are dorsopathies, located in a sixth place of morbidity for outpatient consultation, with 3.2%, and which occurs in all stages of adult life: 2.4% in young adults, 5.6% in adults and 6.9% in older adults, and even in teenagers, with 1.3%, a situational context that had not occurred in recent decades⁽²⁾.

In this way, an adequate evaluation of the spine is of utmost importance, especially at the level of the lumbosacral spine, since in this region there is greater symptomatology, being the objective of clinical and especially radiological review because it is the most useful diagnostic. Currently, magnetic resonance images stand out for allowing the visualization of anatomical information at the spinal and vertebral level with high contrast resolution, having as a fundamental part the T2-weighted image sequence that demonstrates the differentiation between cerebrospinal fluid with the other structures of the vertebromedullary region. Therefore, it has a sensitivity and specificity of 85.5%, close to 100% in oncological and inflammatory pathology^(3,4).

However, traditionally the clinical and especially radiological evaluation of the spine in general has been limited to the region that is presumed to be affected by various limitations, despite the fact that not all pathological types will affect a single region, such as herniated discs with a greater lumbosacral settlement, spondyloarthropathies in the lower back with the likelihood of involvement in adjacent segments, and others that are clinically silent such as vertebral hemangiomas, located mainly at the dorsal level but also at other levels^(5,6).

Based on this, some method is required to visualize the total spine, such as the panoramic sequence or also called panoramic image, which makes it possible to see the spine in a single sequence with modern magnetic resonance imaging systems. This allows the acquisition of images in the sagittal plane of the entire axis of the spine, taking only a few additional minutes compared to the traditional examination, without the need for repositioning the patient, and only planning it from the acquisition station in the MRI Scanning Room, where the acquisition time will

vary according to each sequence^(7,8).

The technique is based on a direct application of the Composing Software, which allows to show an image resulting from other sequences that were acquired in advance. This was traditionally only done in a later post-processing of images, but now it can be obtained automatically by pre-planning the sequences of interest in alignment with what your acquisitions are achieved with the composite image minutes later. This possibility means a notable optimization in terms of the use of extra time and additional platform for image post-processing^(8,9).

Considering that the T2 sequence is a pattern and a basic part of any study of the spinal cord, the fact of using a panoramic sequence enhanced in T2 would be of great contribution and utility to the usual study of the lumbosacral spine; this is because it would allow additional information to be obtained. Therefore, its analysis would serve as a recommendation to opt for its performance due to its contribution and benefit in the diagnosis. In view of this, the objective was to analyze the application of this sequence for the study of the lumbosacral spine by magnetic resonance imaging (MRI).

METHODS

Study design

A retrospective and cross-sectional study was carried out, from January to June 2016, in a group of adult patients whose ages were between 18 and 60 years of age. An MRI study of the lumbosacral spine from an outpatient consultation at a private health services institution in Lima was performed.

Population and sample

The population was made up of 357 patients who had MRI of the lumbosacral spine, whose sample was obtained with the proper formula for a finite population:

$$n = \frac{N (Z_{\alpha}^2)(p) (1 - p)}{(d^2)(N - 1) + (Z_{\alpha}^2)(p)(1 - p)}$$

In the formula, a prevalence equivalent to 0.5 was considered, with a precision of 0.05 and a significance level of 0.05, resulting in a sample of $n = 186$ cases. The applied sampling was stratified probabilistic, whose criterion was to consider the life stages included in the cases, both young adults aged 18-30 years and adults properly speaking aged 31-60 years. The population comprised 71 young adults and 286



adults, with which 37 cases of young adults and 149 cases of adults were selected under the same degree of proportionality, all randomly assigned, thus making up 186 cases of the total sample.

Collection and evaluation instrument

A collection sheet was applied, consisting of a general sheet and an analytical sheet, the data of which were filled in considering the request for a radiological study and the examination performed respectively, using the systematic observation technique. The first sheet allows collecting basic data such as gender and stage of life of the patient, as well as the diagnostic presumption to perform the examination, and the second sheet collects if findings were presented and in which pathological groups and subgroups they could be classified. The examinations were carried out on a Siemens MAGNETOM Aera 1.5 Tesla MRI scanner, using the Spine 32 antennas (attached to the equipment table) and Body 18 (placed at the abdominal level referring to the lumbosacral spine), in which the study was acquired specific in its usual form as well as panoramic T2 Sequence using just an additional 3:37 minutes.

Statistical analysis

A data matrix was prepared using the Microsoft Excel 2016 software for the corresponding collection, creating contingency tables with a subsequent verification of the data obtained. For processing, the statistical software R for Windows, Version 3.1.2, was used, making the corresponding frequency distribution for the different findings and allowing the calculation of means and trends. Likewise, the normal distribution was verified in the data obtained by means of the Kolmogorov-Smirnov test and with this apply the hypothesis test for a proportion, considering:

- Null hypothesis (H0): The acquisition of the panoramic T2 Sequence in the lumbosacral spine does not allow 50% more findings to be located in contrast to a routine examination.
- Alternative hypothesis (H1): The acquisition of the panoramic T2 Sequence in the lumbosacral spine does allow 50% more findings to be located in contrast to a routine examination.

Ethical aspects

The study was carried out based on ethical considerations and good practices, with the authorization of the Academic and Research Directorate of Clínica Internacional, from whose San

Borja headquarters the radiological examinations were obtained after coordination with the headquarters of the Center for Diagnostic Imaging and Supervision of the Magnetic Resonance Area, respecting the confidentiality of the information collected for the exclusive use of this investigation.

RESULTS

The ages of the patients who had magnetic resonance imaging ranged from 18 to 60 years and the median achieved was 40 years. Reviewing the selected cases based on life stage, adults themselves (from 31 to 60 years) were 80.1%, while young adults (from 18 to 30 years) represented 19.9%. Likewise, the female gender constituted 53.8% and the male gender 46.2%, and in which total of cases the most frequent diagnostic presumption was the herniated discs, with 52.7%.

In general, of 186 examinations in total, there were 5 cases that presented a normal diagnosis in the traditional study and with the application of panoramic T2 sequence. Therefore, the remaining 181 cases had some finding, regardless of the acquired segment of the spine. Of these 181 mentioned, the usual lumbosacral study had a total of 414 findings.

In the lumbosacral spine, degenerative pathologies were seen as the most frequent findings, occurring in 93% of cases. Of these, herniated discs were the most common with 57%, the majority of which comprised disc extrusion in 40.6%. Likewise, there were disc protrusion in 37.9% and in fewer disc migration with only 21.5%, continuing with lumbar disc degeneration and modic changes with 19.5% and 9.9% respectively, having as a finding less frequent to spondylolysis with only 0.5%. The other findings were congenital anomalies (5.3%) and neoplastic pathology (1%, represented by hemangiomas as the only type of tumor) and, with less than 1% of cases, there were inflammatory pathologies (0.5%) and traumatic injuries (0.2%). Among the congenital anomalies, the so-called transition anomalies stood out, such as lumbarizations in 50% (conversion of the S1 vertebra) and sacralizations in 36.4% (conversion of the S5 vertebra). Herniated discs located in the lumbosacral spine were 52.9%: disc extrusion accounted for 21.5%, disc protrusion accounted for 20%, while only 11.4% were disc migration, given in 167 patients (Table 1).

Table 1. Findings obtained by routine study by MRI of Lumbosacral spine.

Specific diagnostic findings	Type of Pathology in Lumbosacral Spine							
	Degenerative		Congenital		Neoplastic		Total	
	n	%	n	%	n	%	n	%
Disc protrusion	83	21.6%					83	20.0%
Disc extrusión	89	23.1%					89	21.5%
Disc migration	47	12.2%					47	11.4%
Disc degeneration	75	19.5%					75	18.1%
Modic type II	21	5.5%					21	5.1%
Modic type I	17	4.4%					17	4.1%
Schmorl's nodes	7	1.8%					7	1.7%
Spondylolysis	2	0.5%					2	0.5%
Other degenerative types	44	11.4%					44	10.6%
Lumbarization			11	50.0%			11	2.7%
Sacralization			8	36.4%			8	1.9%
Other congenital types			3	13.6%			3	0.7%
Hemangioma					4	100%	4	1.0%
Other types Neoplastic					0	0%	0	0%
Other pathologies Vertebro-medullary							3	0.7%
Totals by types	385	100%	22	100%	4	100%	414	100%
Absolute total	385	93.0%	22	5.3%	4	1.0%	414	100%

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Of the 181 previously mentioned cases, findings at the cervical and dorsal spine level were also noted by application of panoramic T2 sequence, which were 117 and 46, that is, 163 additional findings. At the cervical spine level, there were basically degenerative pathologies, in 99.1%, highlighting herniated discs, with 59.5%, of which 58% included protruding hernias (especially in the C5-C6 disc), with extruded hernias in 39.1% and finally migrated hernias in 2.9% (Figure 1), followed in 28.4% by disc degenerations. It should be mentioned that congenital anomalies were also presented in 0.9%, represented by hydrosyringomyelia. It should be noted that localized hernias accounted for 59% of cervical lesions, which in turn included protruded hernias in 34.2% while 23.1% consisted of extruded hernias and only 1.7% were migrated hernias.

On the other hand, in the dorsal spine there was also a higher percentage of degenerative pathologies, in a frequency of 81.7%, where herniated discs predominated in more than half of the cases (51.7%), including protruding hernias in 70% (especially in the D7-D8 disc) and 30% extruded hernias (Figure 1); apart from Schmorl's nodules with 24.1% and disc degenerations with 20.7%. The remaining 18.3% in the dorsal segment corresponded to neoplasm pathologies, whose lineage was specifically the vertebral hemangioma. The dorsal hernias presented were 42.3% of the total findings, comprising both protruding hernias, in 29.6%, and extruded hernias, in 12.7%. Therefore, the main findings located outside the lumbosacral spine were hernias, given in 77 patients, both at the cervical level, in 59%, and at the dorsal level, in 42.3% (Table 2).



Table 2. Findings obtained outside the Lumbosacral spine by Panoramic T2 sequence.

Specific diagnostic findings	Type of Pathology outside the Lumbosacral spine								
	Degenerative		Congenital		Neoplastic		Total		
	n	%	n	%	n	%	n	%	
Findings in the Cervical Spine	Disc protrusion	40	34.5%					40	34.2%
	Disc extrusion	27	23.3%					27	23.1%
	Disc migration	2	1.7%					2	1.7%
	Disc degeneration	33	28.4%					33	28.2%
	Other degenerative types	14	12%					14	12%
	Hydrosyringomyelia			1	100%			1	0.9%
	Other congenital types			0	0%			0	0%
	Totals by type	116	100%	1	100%			117	100%
	Absolute total at Cervical level	116	99.1%	1	0,9%			117	100%
Findings in the Dorsal Spine	Disc protrusion	21	36.2%					21	29.6%
	Disc extrusion	9	15.5%					9	12.7%
	Schmorl's nodes	14	24.1%					14	19.7%
	Disc degeneration	12	20.7%					12	16.9%
	Other degenerative types	2	3.4%					2	2.8%
	Hemangiomas					13	100%	13	18.3%
	Other neoplastic types					0	0%	0	0%
	Totals by type	58	100%			13	100%	71	100%
	Absolute total at Dorsal level	58	81.7%			13	18.3%	71	100%

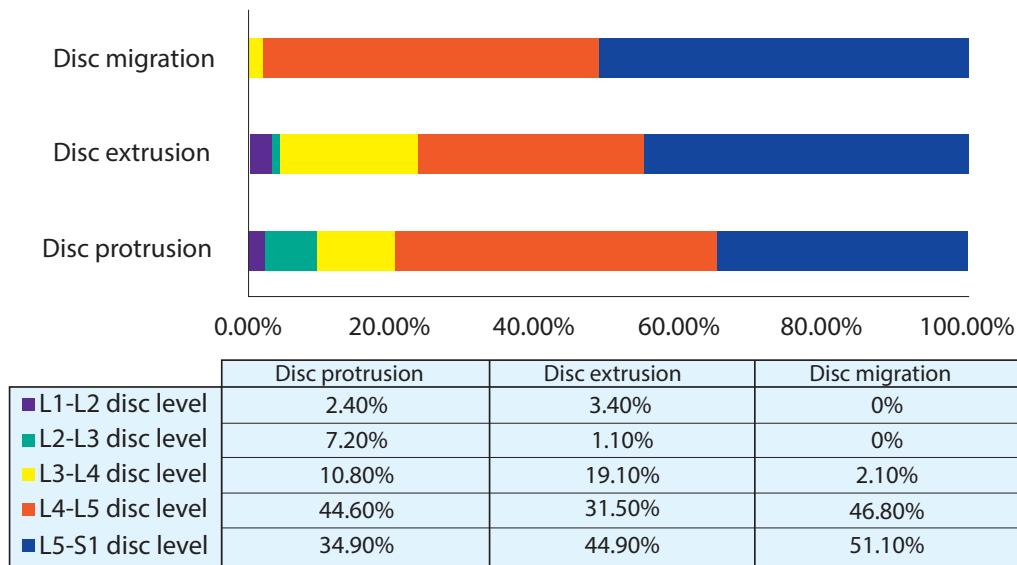
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Regarding the location of herniated discs at the level of the lumbosacral spine, which has been the most frequent injury, it occurred mainly at the level of the L5-S1 disc in 42% of cases, although it also occurred in the other intervertebral discs: L4- L5 with

39.7%, L3-L4 with 12.3%, L2-L3 with 3.2% and L1-L2 with 2.3%. The L5-S1 disc was the main location of extruded and migrated hernias, with 44.9% and 55.1% respectively, unlike protruding hernias located mainly in the L4-L5 disc, with 44.6% (Graph 1).



Figure 1. MRI of 2 cases with application of panoramic T2 Sequence: 1. 29-years-old pt. (A), where disc extrusion in L5-S1 is denoted as well as disc protrusion in C5-C6 (images B and C respectively). 2. 39-year-old pt. (D), where disc extrusion in L4-L5 is denoted as well as disc protrusion in D7-D8 (images E and F respectively).



Graphic 1. Anatomical location of Herniated lumbar disc.

The application of the panoramic T2 image for examination of the lumbosacral spine by magnetic resonance imaging was verified using hypothesis testing for a proportion, taking into consideration that, as H0, the technique does not allow 50% more findings to be located than in a regular examination, and that, as H1, the technique does allow 50% more findings to be located in contrast to a regular test. In this way, the Sig value of the corresponding Zcal was obtained from the findings at the level of the lumbosacral segment in the conventional exam and the amount of findings obtained by adding the panoramic T2 sequence, obtaining Sig = 0.031, which being less than 0.05, rejecting the null hypothesis and therefore at 95% confidence level, it can be stated that the application of this. This sequence does allow 50% more findings to be located, showing that it is useful for MR imaging of the lumbosacral spine.

DISCUSSION

The results demonstrate that the application of the panoramic T2-weighted sequence for the lumbosacral spine examination is valid. Therefore, the importance of magnetic resonance imaging in the evaluation of the spine is first reaffirmed, as stated by Aroche⁽¹⁰⁾ and Medina⁽¹¹⁾. Second, that requests for examination with a specific presumption justify their performance for a due evaluation, since they allow to see early changes and/or incipient lesions and thus have a clinical relevance, as explained by Fretes⁽¹²⁾, Kovacs⁽¹³⁾, Millán and Cols⁽¹⁴⁾, and Rodríguez⁽¹⁵⁾.

Analyzing, the hypothesis verification defined that 50% more findings are located with the panoramic sequence in question, unlike the usual study. This is similar as reported by Méndez⁽¹⁶⁾, which obtained 74.8% of additional findings using STIR sequence, applying post-process after examination and considering elderly patients. In addition, what is proposed by Schiappacasse⁽¹⁷⁾ and Campos⁽¹⁸⁾ is supported, where it was proposed to use a sagittal sequence for the entire column. It also confirms what was concluded by Burbano⁽¹⁹⁾ and Campos⁽¹⁸⁾, where the T2-weighted image was superior for the various anomalies. In relation to this, what was expressed by Tito⁽²⁰⁾, is corroborated, who indicated the importance of including this sequence in the examination of an image that reveals adjacent lesions to those presented in the specific initial evaluation segment.

Reviewing the findings, there was the presence of a greater number of degenerative pathologies, with 93% of findings. The main ones were herniated discs, with a frequency of 60%, which coincided with the studies by Ortega⁽²¹⁾ at the Centro Médico Ecatepec, of the Instituto Mexicano de Seguridad Social, with the studies by González⁽²²⁾ at the Hospital Universitario Nacional de Colombia, and with the findings of Enríquez⁽²³⁾ in the Clínica Pichincha, whose results were also the most outstanding, with 40.2%, 33.7% and 32.7% respectively. The highest percentage were disc extrusion, in 40.6%, then protruding hernias, with 37.9%. These findings were different and at

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the same time with a lower percentage compared to the studies by Ortega⁽²¹⁾ and González⁽²²⁾, as well as the study of hernias carried out by Solano and Ávila⁽²⁴⁾ at the Hospital Carrasco de Cuenca, of the Instituto Ecuatoriano de Seguridad Social, in which disc protrusions were mainly presented, with figures equivalent to 73.3%, 87.6% and 96.7% in each case.

Similarly, it was found that the main location of the different types of hernias presented was mainly at the level of the L5-S1 disc in 42% of cases. This result coincided with the theses of Gil⁽²⁵⁾ in a Sanitary Production Company of Lima, with those of Rivero⁽²⁶⁾ in the Hospital Nacional Dos de Mayo of the Ministry of Health, with those of Quispe⁽²⁷⁾ in the Clínica La Luz de Lima, that of Medina⁽²⁸⁾ in the Hospital Nacional "Ramiro Prialé Prialé", of the Social Security - EsSalud, and with those of Román⁽²⁹⁾ in the Hospital Nacional "Luis N. Sáenz" of the Peruvian National Police, in whose results it was also the main location, with 66%, 62%, 39.1%, 34.4% and 34% respectively, fully endorsing that it is the most affected intervertebral disc in people regardless of the activity that could develop and the population group to which they could belong.

Likewise, findings were obtained in both the cervical and dorsal spine, acquiring the panoramic T2 sequence. In both segments, the highest frequency was also given by herniated discs presented in 59.5% and 51.7% of cases, respectively. With this, it is confirmed that herniated discs are the most frequent pathology of the entire spinal axis, and not only at the lumbosacral level. Clinically, the latter is the area

with the greatest symptomatological settlement due to the presence of some typical risk factors of the activity, workload or rhythm of people's lives.

CONCLUSION

Through the present investigation, it was reaffirmed that the lumbosacral spine resonance is a valuable exam because it allows the discard and/or evaluation of multiple findings with precision through the possibility of differentiation. Degenerative entities are the most frequent, and it was shown that the acquisition of the panoramic image in T2 is useful because it helps to locate a greater number of conditions at the general level of the spine as in non-contiguous segments. Therefore, this sequence should be considered as a fundamental element to find additional information that contributes to a better diagnosis, compared to the usual lumbosacral magnetic resonance.

In this way, it was determined that the application of the panoramic T2 Sequence for lumbosacral magnetic resonance is absolutely functional and useful in the diagnostic evaluation because it allows locating 50% more additional findings compared to the usual study of the lumbosacral segment. The main findings in the lumbosacral segment, as well as at the cervical and dorsal level, were degenerative diseases, predominantly herniated discs in a greater proportion. The most frequent lumbosacral location was the L5-S1 disc.

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BIBLIOGRAPHIC REFERENCES

1. Ministerio de Salud. Análisis de la Situación de Salud del Perú, 2018. Lima: Ministerio de Salud; 2019.
2. Ministerio de Salud. Repositorio Único Nacional de Información en Salud. Lima: Ministerio de Salud (Internet). 2020 (Citado 18 nov 2020). Disponible en: <http://www.minsa.gob.pe/reunis/index.asp?op=5>
3. Fleckenstein P, Tranum J. Bases anatómicas del diagnóstico por imagen. 3a ed. Barcelona: Elsevier; 2014.
4. Herring W. Radiología básica. Aspectos fundamentales. 4a ed. Madrid: Elsevier; 2020.
5. Burgos J, Izquierdo E, Sarramea H. Patología de la Columna Vertebral. Madrid: Editorial Médica Panamericana; 2019.
6. Cura J del, Pedraza S, Gayete A, Rovira A. Radiología esencial. Tomo I. 2a ed. Madrid: Editorial Médica Panamericana; 2019.
7. Pastrana M, González C. Técnicas de imagen por resonancia magnética. Madrid: Arán Ediciones S.L. 2015
8. Siemens. MAGNETOM Aera. Erlangen: Siemens; 2015.
9. Siemens. Imanes, espines y resonancias. Una introducción a los fundamentos de la resonancia magnética. Erlangen: Siemens; 2015.
10. Aroche Y, Pons L, De La Cruz A, González I. Patogenia, cuadro clínico y diagnóstico imagenológico por Resonancia magnética de las Hernias discales. MEDISAN. 2015; 19(3): 391-492.
11. Medina C. Correlación de los hallazgos tomográficos y en resonancia magnética en pacientes con discopatías de columna lumbar, atendidos en el Centro de Alta Tecnología del Hospital Escuela Antonio Lenin Fonseca, enero 2014 a enero 2015. Tesis de Especialidad. Managua, Nicaragua. Facultad de Ciencias Médicas, Universidad Nacional Autónoma de Nicaragua; 2016. 61 pp.
12. Fretes C. Papel de la RMN en diagnóstico, pronóstico y manejo de la lumbalgia y radiculopatía. Rev Bol Dolor. 2015; 9(2): 33-39.
13. Kovacs F, Arana E. Patología degenerativa en la columna lumbar. Radiología. 2016; 58(1): 26-34.
14. Millán E, Cabrera A, Muñiz J, Sola C, Zubia J. Indicaciones de la resonancia magnética en la lumbalgia de adultos. Rev Calid Asist. 2014; 29(1): 51-57.
15. Rodríguez C. Utilidad de la Resonancia magnética en pacientes con dolor lumbar inespecífico. Informes de Evaluación de Tecnologías Sanitarias. Madrid, España: Ministerio de Sanidad, Servicios Sociales e Igualdad – Unidad de Evaluación de Tecnologías Sanitarias de la Comunidad de Madrid; 2013. 54 pp.
16. Méndez R. Beneficios de la inclusión de una secuencia panorámica de columna vertebral en STIR en los protocolos del raquis en pacientes de 18 a 80 años en Clínica Tomonorte 2013-2014. Tesis. Lima, Perú. Facultad de Medicina, Universidad Nacional Mayor de San Marcos; 2014. 49 pp.
17. Schiappacasse G, Díaz J, Alwayay P. Protocolo abreviado de resonancia magnética en espondiloartritis: más allá de la sacroileítis. Rev Med Chile. 2015; 143(1): 905-912.
18. Campos L y col. Valor de la resonancia magnética y del protocolo de cuerpo completo en mieloma múltiple. Med Int Méx. 2014; 30(1): 745-754.
19. Burbano H, Belalcázar E, Fernández S. Resonancia magnética de la columna lumbar: lo que el radiólogo debe conocer antes de elaborar un reporte. An Rad Méx. 2014; 13(1): 292-305.
20. Tito H. Importancia de la Secuencia T2 Panorámica en Columna Vertebral – Instituto de Imágenes Médicas. Tesis de Especialidad. Lima, Perú. Facultad de Tecnología Médica, Universidad Nacional Federico Villarreal; 2019. 54 pp.
21. Ortega J. Hallazgos más frecuentes en Resonancia Magnética de cambios osteodegenerativos en la Columna Lumbar en pacientes jóvenes con lumbago en el Centro Médico ISSEMYM Ecatepec. Tesis de Especialidad. Ciudad de México, México: Facultad de Medicina, Universidad Autónoma de México; 2014. 61 pp.
22. González E. Hallazgos degenerativos de Columna lumbar en Resonancia magnética de pacientes con dolor lumbar. Tesis de Especialidad. Bogotá, Colombia: Facultad de Medicina, Universidad Nacional de Colombia; 2013. 49 pp.
23. Enríquez D. Identificación de Patologías degenerativas del Disco intervertebral de Columna lumbar en Pacientes mayores de 40 años por Resonancia magnética en la Clínica Pichincha, Junio–Diciembre 2015. Tesis. Quito, Ecuador. Facultad de Ciencias Médicas, Universidad Central del Ecuador; 2016. 171 pp.
24. Solano P, Ávila L. Prevalencia de Hernia de disco en Columna Lumbar diagnosticada por Resonancia Magnética en el Hospital José Carrasco Arteaga IESS Cantón Cuenca. Mayo 2014–Octubre 2014. Tesis. Cuenca, Ecuador: Facultad de Ciencias Médicas, Universidad de Cuenca; 2014. 43 pp.
25. Gil D. Alteraciones discales en Resonancias magnéticas de Columna lumbosacra en Postulantes asintomáticos a una Empresa de Sanitarios. Tesis de Maestría. Lima, Perú. Facultad de Medicina, Universidad Nacional Mayor de San Marcos; 2017. 45 pp.
26. Rivero R. Prevalencia de Hernia discal en Columna Lumbar según Resonancia magnética, Enero–Abril 2015. Tesis. Lima, Perú. Facultad de Tecnología Médica, Universidad Nacional Federico Villarreal; 2019. 49 pp.
27. Quispe J. Hernia de Núcleo Pulposo a través de Resonancia magnética en Columna lumbar Lima 2017. Tesis. Lima, Perú. Facultad de Tecnología Médica, Universidad Nacional Federico Villarreal; 2018. 49 pp.
28. Medina M. Hallazgos radiológicos de la Hernia discal lumbar por Resonancia magnética, en pacientes del Hospital Nacional “Ramiro Priale Priale”- EsSalud, Huancayo-2017. Tesis. Huancayo, Perú. Facultad de Ciencias de la Salud, Universidad Peruana Los Andes; 2019 80 pp.
29. Román R. Hernia de Núcleo Pulposo de Columna lumbosacra de Policías en actividad según Resonancia. Tesis de Especialidad. Lima, Perú. Facultad de Tecnología Médica, Universidad Nacional Federico Villarreal; 2018. 43 pp.