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Original article

Comparison between radiographic and ultrasound angle measurements in the assessment of idiopathic scoliosis

Samra Pjanić,
Goran Talić,
Dragana Bojinović-Rodić

Institute for physical and rehabilitation medicine „dr Miroslav Zotović", Banja Luka, The Republic of Srpska, Bosnia and Herzegovina

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Corresponding author:
Samra Pjanić, MSc
Skendera Kulenovića 30B,
78 000 Banja Luka
samra.pjanic@hotmail.com

Summary

Introduction. Radiological assessment is still being considered a golden standard when it comes to detection, follow-up and treatment of idiopathic scoliosis. However, it has universally been proven that radiation is cumulative and that it has oncogenic effects. For this reason, nowadays it is becoming increasingly popular to perform spinal ultrasounds using the Scolioscan® device. Relevant research has shown diagnostic potential of the device and its application in the assessment and monitoring of idiopathic scoliosis. The aim of our study has been to compare angle measurements in ultrasound and radiological spinal images and to determine the role of ultrasound in the assessment process and follow-up of patients with idiopathic scoliosis.

Methods. This cross-sectional study has been conducted on a sample of 172 patients. Its participants are boys and girls, patients of the Team for Scoliosis that operates within the Department for Habilitation and Rehabilitation of Children in the Institute for Physical Medicine and Rehabilitation ''Dr Miroslav Zotović", Banja Luka, the Republic of Srpska. Radiography and ultrasound of the spine have been performed on every patient on the same day. Three specially trained operators administrated the ultrasound scanning, while four raters (i.e. doctors) measured the radiographic Cobb angle and the ultrasound Scolio angle. Patients have been divided into groups according to gender, curve location and curve severity.

Results. In general, ultrasound angles are shown to be smaller compared to Cobb angles, which has been confirmed in previous studies as well. The mean difference between Cobb and Scolio angle is statistically, but not clinically significant (3.62±4.39°, p<0.001). There is a statistically significant good positive correlation between the Cobb and the Scolio angle (r=0.675, p<0.001). According to groups, our results indicate a better correlation in the girls group (r=0.688, p<0.001) as opposed to the boys group (r=0.632, p<0.001). The same holds true for the thoracic group (r=0.736, p<0.001), compared to the (thoraco) lumbar group (r=0.654, p<0,001). A stronger correlation can also be seen in the group with a Cobb angle that is equal to or higher than 20° (r=0.518, p<0.05) than in the group with a Cobb angle lower than 20° (r=0.462, p<0.001).

Conclusion. The results of our study confirmed a good validity of the ultrasound method using the Scolioscan® device, compared to conventional radiography, taking into account clinically insignificant differences in angle measurements. Using only B-mode ultrasound images – with no additional software analysis, nor 3D reconstruction of spinal deformities – proved to be sufficient for a follow-up of scoliosis, with respect to other parameters, such as clinical assessment, back surface topography, etc.

Key words: idiopathic scoliosis, ultrasound, radiography, imaging

Introduction

Idiopathic scoliosis is a three-dimensional spinal deformity with unknown etiology [1] that occurs in seemingly healthy children during growth, prominently progressing while in puberty and adolescence. This condition occurs more frequently in girls than in boys, especially during their growth spurt [2]. If scoliosis exceeds a Cobb angle of 30° –and particularly 50° [3] – there is a higher risk of health problems in adulthood [4]. A spinal deformity is structural and manifests in the form of vertebral changes with lateral deviation, rotation and impaired sagittal profile. Idiopathic scoliosis can be diagnosed exclusively via AP or PA radiography of the entire spine. According to SRS, the diagnosis of scoliosis can be established if the Cobb angle is 10° at minimum, with an axial rotation [1].

Radiological assessment is still being considered a golden standard when it comes to the detection, follow-up and treatment of scoliosis [5]. However, it is a proven fact that radiation is cumulative and has oncogenic effects, thereby increasing the risk of breast cancer in girls [6], as well as significantly contributing to leukemia and prostate cancer [7]. Consequently, using devices with a low dose of radiation (EOS) or no radiation at all (ultrasound, back surface topography) has become more frequent lately. Even though such methods still fail to replace conventional radiography in the treatment of idiopathic scoliosis, in recent years they have been used more frequently due to growing evidence of their reliability and validity.

Performing spine ultrasounds via the Scolioscan® device has become more popular and accessible worldwide. Relevant studies have shown its diagnostic potential and application in the assessment of idiopathic scoliosis [8,9,10,11]. It has also been demonstrated that the ultrasound can be used for the assessment of spinal flexibility, as well as for the prediction of in-brace correction [12]. The main advantage of ultrasound, compared to conventional radiography, is a complete absence of radiation. This enables its unlimited application, without possible health consequences in patients. Nevertheless, there are differences between these two methods, particularly in angle measurement assessments. Compared to conventional radiography, ultrasound imaging is unable to capture the patient's pelvic area. It is therefore inadequate in assessing the skeletal maturity according to the Risser sign and, consequently, the risk of progression. Also, it is not possible to assess cervical and upper thoracic curves, as ultrasound scanning reaches only up to the first thoracic vertebra. A 3D spine reconstruction using additional software (ScolioStudio) is possible, but it is more time-consuming and requires further education of clinicians.

Previous research has demonstrated a good to very good validity and reliability for the ultrasound assessment of scoliosis. It has been stated that ultrasound can reduce the need for radiographs during follow-ups and could additionally be used for scoliosis screening [13].

The aim of our study has been to compare angle measurements in ultrasound and radiological spine images and to determine the role of ultrasound when it comes to the assessment and follow-up of patients with idiopathic scoliosis.

Methods

This cross-sectional study has been conducted with the approval of the competent Ethical Committee. The sample consists of 172 patients, boys and girls, who have been patients of the Team for Scoliosis that operates within the Department for Habilitation and Rehabilitation of Children in the Institute for Physical Medicine and Rehabilitation ''Dr Miroslav Zotović'' in Banja Luka, the Republic of Srpska. The Team for Scoliosis consists of doctors – specialists of physical and rehabilitation medicine – therapists and orthotists who conduct conservative treatment for all types of scoliosis, especially idiopathic scoliosis, according to SOSORT guidelines [1].

Radiography and ultrasound scans of the spine were performed for each patient on the same day. If, during the first examination in our facility, a spinal deformity is suspected, or a clinical deterioration is observed amidst a regular follow-up, spine radiography is performed. Indication for radiography is based on anamnestic data, the presence of risk factors and a detailed clinical assessment of the patient, including measurements of the angle trunk rotation with a scoliometer.

Our facility administers a digital radiography of the entire spine for the detection of scoliosis with possibility of spine measurements using TraumaCad® software. The diagnosis of scoliosis is established if the measured Cobb angle is higher than 10°, with rotation aspects of the vertebrae.

The Scolioscan® device system enables ultrasound imaging of the spine. Scolioscan® is manufactured by Telefield Medical Imagining Ltd. in Hong Kong, China and is comprised of a hardware system that enables the scanning process, as well as a software solution (Scoliostudio) for additional adjustments and 3D spine reconstruction. Its most important feature is a radiation-free scoliosis assessment. The short comings of Scolioscan® include patient's weight limit of up to 150 kg, as well as the presence of metal and magnet implantants in patients (i.e. pacemaker, defibrillator, cochlear implantant).

The scanning process is fast and effortless. The patient only needs to maintain a stable, but relaxed posture for about 45 seconds to one minute, for the duration of the scanning process (Picture 1). The device is adjustable to the patient's height and width. Three operators (technicians), with a successfully completed special training, administer the ultrasound scanning. Due to the absence of radiation, one can repeat the procedure as many times as needed, without causing any harm to the patient.

Picture 1. Scanning process on Scolioscan® device

After the scanning process, a B-mode image of the spine is produced, which has been used in this study. Additional analysis and 3D spine reconstruction that are available in the Scoliostudio software program have not been employed in this study. Different raters (i.e. doctors) have been in charge of the measurement of radiographic and ultrasound angles, in order to avoid subjectivity and its possible impact on the measurement process.

A Scolio angle is an ultrasound angle that is defined in our study by the same neutral vertebrae as a radiographic Cobb angle. In order to minimize the difference in angle measurements – that are possible due to a pronounced vertebral rotation in some curves – we have applied manual ultrasound measurements with transverse processes as reference points. Cobb angle is defined on digital radiography by superior endplate of the upper neutral vertebra and inferior endplate of lower neutral vertebra which are chosen by the person who takes measurements (Picture 2). Both Cobb and Scolio angles are measured in degrees.

Picture 2. Radiographic Cobb angle measured on digital radiography

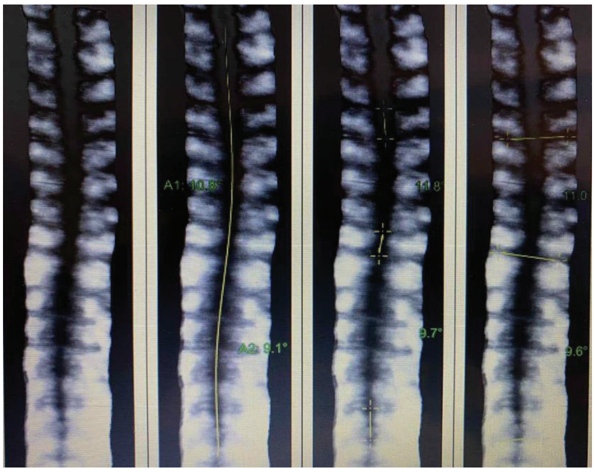
Factors that can affect these differences in image quality are: high BMI, significant vertebral rotation, impaired sagittal profile, and prominent spinal processes or scapulae.

The inclusion criteria for this study concern patients with idiopathic scoliosis, with whom our Team has developed a good cooperation during the clinical and diagnostic assessment. While the ultrasound scanning is being performed, it is required of patients to maintain an upright position for up to one minute, for the duration of the scanning, without any movement whatsoever.

Non-cooperative patients, patients with secondary scoliosis, patients with high thoracic and cervicothoracic curves, as well as patients with a BMI higher than 85 percentiles have been excluded from the study. The reason for the latter is that the ultrasound scans only up to the first thoracic vertebra (Th1), which makes it impossible for the curves to be visible. Patients with a high BMI result in having low quality ultrasound images, making the assessment difficult and inaccurate, thus requiring additional adjustments and reconstruction in the Scoliostudio software system.

When it comes to patients with multiple scoliotic curvatures, only the primary curve has been considered in the measurement process.

There are three types of Scolio angle measurements: automatic, manual with a spinous process (SP) as a measurement reference point and manual with a transverse process (TP) as a measurement reference point (Picture 3). In order to provide greater accuracy and increase the comparability between angles, we have been using manual measurements, as well as the same neutral vertebrae that have been identified in X-ray and in ultrasound imaging. Landmarks that have been used for the measurement are transverse processes. Namely, curves with greater rotation have displaced spinous processes, which can lead to imprecise measurements and increase the discrepancy between radiological and ultrasound angles. Patients have been divided into three groups according their gender, primary curve location and curve severity. The group created based on the primary curve location has additionally been divided into two sub-groups: thoracic and (thoraco) lumbar group. The latter includes thoracolumbar and lumbar curves. This division is based on findings indicating that there are differences in the measurement of ultrasound angles in thoracic and (thoraco) lumbar curves.



Picture 3. Automatic, manual SP and TP ultrasound measurements

Based on the severity of their curve, patients have been divided into two groups: having a Cobb angle below 20° and having a Cobb angle equal or above 20°. This threshold is in accordance with the recommendations for brace treatment, i.e. a Cobb angle that is equal to or higher than 20°.

Statistical data analysis has been performed using the program „SPSS for Windows 21". To determine the correlation between Cobb and Scolio angle – in total and according to groups – a Pearson's correlation test has been conducted. To examine whether there are statistically significant differences between variables, a t-test with unequal variance has been performed. The level of significance was set to $p < 0.05$. Logistic regression analysis has been used to test the impact of the predefined predictors (gender, curve location and curve severity).

Results

Our sample consists of 172 patients with juvenile and adolescent idiopathic scoliosis (94 females and 78 males), with a mean age of 12.01 years (SD ± 2.35, range 5 to 16).

The mean Cobb angle is 12.48° (SD ± 5.95°, range 4 to 43°) and the mean Scolio angle is 8.86° (SD ± 3.98, range 2.2 to 27.1°), as presented in Table 1.

The mean difference between Cobb and Scolio angle is 3.62° (SD ± 4.39), which is statistically significant ($p<0.001$). When expressed in percentages, the value is 23.55% (SD ± 29.50).

Table 1. Mean values and range of Cobb angle and Scolio angle in total

	X-ray (° Cobb)				Ultrasound (° Scolioscan)		
	n	M	min	max	M	min	max
TOTAL	172	12.48±5.95	4	43	8.86±3.98	2.2	27.1

Table 2. Mean values of Cobb angle and Scolio angle according to gender

X - ray (° Cobb)				Ultrasound (° Scolioscan)		
n	boys	girls	total	boys	girls	total
172	10.99±4.19	13.72±6.86	12.48±5.95	8.16±3.56	9.44±4.22	8.86±3.98

Table 2 presents the data according to gender. In the boys group, the mean Cobb angle is 10.99° (SD±4.19, range 4 to 28°) and the mean Scolio angle is 8.16° (SD±3.56, range 2.2 to 24.9°). In the girls group, the mean Cobb angle is 13.72° (SD±6.86, range 4 to 43°) and the mean Scolio angle is 9.44° (SD±4.22, range 2.7° to 27.1°).

According to the location of the primary curve, the thoracic group consists of 47 patients, while the (thoraco) lumbar group includes 125 patients. In the thoracic group, the mean Cobb angle is 12.53° (SD±7.45, range 4 to 43°), while the mean Scolio angle is 8.43° (SD±4.18, range 2.8 to 24.9°). In the (thoraco) lumbar group, the mean Cobb angle is 12.46° (SD±5.31, range 5 to 33°) and the mean Scolio angle is 9.02° (SD±3.90, 2.2 to 27.1°). This data is presented in Table 3.

Table 3. Average Cobb and Scolio angle according to curve location

	Cobb angle		Scolio angle
T	47	12.53±7.45	8.43±4.18
(T)L	125	12.46±5.31	9.02±3.90
Total	172	12.48±5.95	8.86±3.98

Table 4 illustrates data of the groups defined according to curve severity. In the group with a Cobb angle lower than 20°, there were 149 patients with a mean Cobb angle of 10.54° (SD±3.47, range 4° to 19°) and a mean Scolio angle of 8.05° (SD±2.98, range 20° to 43°). In the group with a Cobb angle greater than 20°, there were 23 patients with a mean Cobb angle of 24.13° (SD±5.83, range 20° to 43°) and a mean Scolio angle of 14.34° (SD±5.16, range 8.7° to 27.1°).

There is a good positive correlation between angle measurements in radiography and ultrasound imaging (r=0.675, statistically significant p<0.001), as shown in Figure 1.

Based on gender, there was a slight difference in correlation in the girls group (r=0.688), compared to the boys group (r=0.632, p<0.001), in favor of girls.

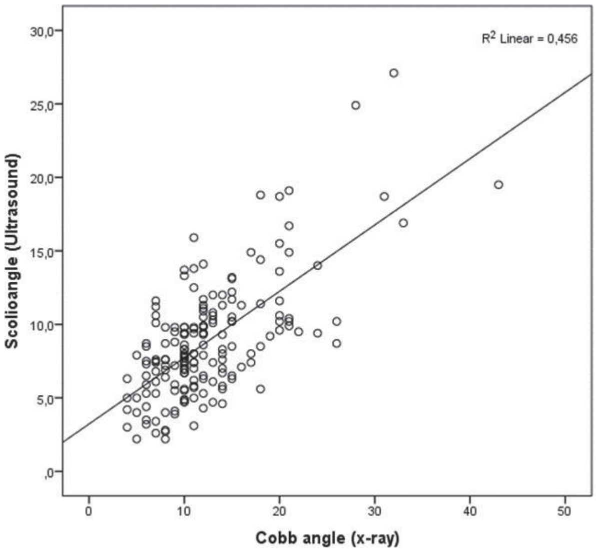


Figure 1. Correlation between radiographic Cobb and ultrasound Scolio angle

According to curve location, the correlation in the thoracic group is r=0.736 and in the (thoraco) lumbar group it is r=0.654 (p<0.001).

According to curve severity, in the group with a Cobb angle lower than 20°, the correlation is r=0.462 (p<0.001), while in the group with a Cobb angle equal or higher than 20° it is r=0.518 (p<0.05).

Table 4. Mean values of Cobb and Scolio angle according to curve severity

	n	X-ray (° Cobb)			Ultrasound (° Scolio angle)		
		M	Min	max	M	min	max
°Cobb<20°	149	10.54±3.47	4	19	8.05±2,98	2.2	18.8
°Cobb≥20°	23	24.13±5.83	20	43	14.34±5.16	8.7	27.1
Total	172	12.48±5.95	4	43	8.86±3.98	2.2	27.1

Two out of three predictors (gender, curve location and curve severity) have a statistically significant contribution to the entire regression model (curve severity and location). The best predictor is shown to be the Cobb angle (odds ratio 1.24).

Discussion

Considering that the ultrasound imaging method has only recently started to become more widely used on patients with scoliosis, the results of our study are very promising, confirming the validity of ultrasound in the detection and follow-up of spinal deformities in children, compared to conventional radiography. Furthermore, it is possible to predict that radiography might be used less frequently in the future, since our results confirm a good correlation in measurements between radiological and ultrasound spine images.

Our study did not question the reliability of the Scolioscan®, since we relied on results from previous studies that proved Scolioscan® to be feasible and reliable, with a mean ICC value of 0.94±0.04 (in the range from 0.88 to 0.97) between two operators and among three raters [13]. Our study was blinded, three operators conducting the scanning process, while four raters being blinded.

The obtained results show the mean difference between radiological and ultrasound angle being 3.62±4.39° ($p<0.001$). Even though there is a statistical significance, the difference is not considered notable in clinical settings. The Cobb angle measurement error lies within the interval of ±5° [14,15], in which no important clinical decisions regarding the treatment options are being made. Hence, one can conclude that the difference between Cobb and Scolio angle cannot be considered significant for the follow-up of patients with idiopathic scoliosis, especially when taking into account additional parameters regarding the treatment decision (i.e. scoliometer readings, back surface topography, etc).

Our results indicate a statistically significant good positive correlation between angle measurements in radiography and ultrasound imaging ($r=0.675$, $p<0.001$). This is significant, since other radiation-free scoliosis assessment methods indicate that a correlation coefficient of at least 0.55 represents a moderate to good correlation [16].

The results according to groups demonstrate a slightly better correlation in the girls group than in the boys group ($r=0.688$ vs. $r=0.632$). Furthermore, a better correlation has been detected in the thoracic group than in the (thoraco) lumbar group ($r=0.736$ vs. $r=0.654$). Additionally, a better correlation could be seen in the group with a Cobb angle equal to or higher than 20°, compared to the group with a Cobb angle lower than 20° ($r=0.518$ vs. $r=0.462$).

The contrast in results for groups categorized according to gender can be explained by the difference in sagittal profile development of girls and boys according to their age. It has been proven that girls enter growth spurt during postural instability [17], which is why spinal deformities and impaired sagittal profiles are more prevalent in girls. Changes in sagittal profile (reduced thoracic kyphosis and lumbar lordosis) can affect the scanning process, the image quality and, consequently, the measurement precision. A better correlation in thoracic curves, compared to (thoraco) lumbar curves, is possibly achieved due to a different anatomical structure of the spine in these two regions. Different sagittal profiles and vertebral rotations (which incorporates the ribs in the thoracic region) can affect the measurement precision.

According to the severity of the curve criteria, we have observed a better correlation in a Cobb angle that is equal to or higher than 20°, which can be explained by a smaller curve range, since there have only been 23 patients in this group.

Ultrasound angles are generally lower than Cobb angles, which has been confirmed in previous studies [13,18]. This can be explained by the fact that ultrasound measurements include more posteriorly located structures (spinous and tranverse processes), while radiography uses more anteriorly located structures (vertebral bodies).

The results of our study confirm a good correlation between ultrasound and radiological angle measurements, although not as high as observed in previous studies. Zheng et al. [13] demonstrated a moderate to strong correlation (R2=0.72) between Scolio and Cobb angles for both the thoracic and the lumbar regions. Nevertheless, the difference between Scolio and Cobb angles is shown to be 4.7°and 6.2°, with and without the correlation respectively, using the overall regression equation, which is consistent with our results. Brink et al. [18] found excellent linear correlation between Cobb and Scolio angles – for the thoracic region R2≥0.987 and for the (thoraco) lumbar region R2≥0.970. In the same study, the authors found no significant difference between various ultrasound angle measurements (automatic SP, manual SP, and manual TP). Therefore, our choice of manual measurements with transverse processes (TP) taken as reference points should not have interfered with the results.

The study of Tin-Yan Lee et al. [19], observed very good correlations between Cobb and Scolio angles – R2=0.893 in the thoracic region and R2=0.884 in the lumbar region, with an angle difference of no more than 3.0° for thoracic, and 1.5° for (thoraco) lumbar curves. Compared to this study, our results indicate a greater angle differences, which can possibly be ascribed to the difference in Cobb angle intervals of patients (8-70° vs.4-43°).

In their prospective study with a large number of patients (n=952), Wong et al. [20] confirmed a very good correlation between Scolio and Cobb angles – measured using EOS radiography – that is statistically significant ($p < 0.001$). As it was the case in our study, as well as in previously mentioned studies, a better correlation has been observed in upper spinal curves (r=0.873) than in lower spinal curves (r=0.740).

When comparing the results obtained in our research with other studies, we can observe a contrast in Cobb and Scolio angle correlations. This can be explained by the difference in image quality standards for measurements, as well as differences in the level of staff training and experience. Our study used B-mode ultrasound images for measurements, which are obtained directly after the scanning process without further software analysis or 3D reconstruction. Such a decision has been made for various reasons. Firstly, the reconstruction process is time-consuming and requires additional training. Secondly, in accordance with the previously stated observation, our aim was to examine whether a high quality B-mode image is sufficient for the detection and follow-up of scoliosis. In other studies, additional software adjustments have been conducted with a 3D reconstruction of the spine model, which certainly enables a better visibility and more precise measurements.

Recently, Scolioscan Air has been introduced, the world's first portable ultrasound scoliosis assessment system. It has proven to be sufficiently comparable to Scolioscan® in the assessment of scoliosis, while overcoming its shortcoming of space limitation, and expanding its indications for its application [21].

The usage of ultrasound imaging in the detection and follow-up of scoliosis has become more prevalent worldwide due to its non-radiation feature. Curve measurements obtained via Scolioscan® prove to be highly reliable, with good to excellent correlation with the conventional radiographic Cobb method.

Conclusion

Ultrasound assessment via the Scolioscan® device represents a great step forward in the process of detection and follow-up of patients with idiopathic scoliosis. Despite some shortcomings, the predominant advantage of the ultrasound method is a radiation-free assessment. Scoliosis patients who need long-term monitoring and treatment will be able to avoid radiation-related health issues.

The results of our study confirm a good validity of the ultrasound method via the Scolioscan® device compared to conventional radiography, considering the clinically insignificant differences in angle measurements.

Using B-mode ultrasound images only with no additional software analysis or 3D reconstruction of spinal deformities – proved to be sufficient for the follow-up of scoliosis patients, with respect to other parameters, such as clinical assessment, back surface topography, etc. Nevertheless, at present it is not yet possible to diagnose scoliosis using the Scolioscan® device alone.

It is expected that further research will investigate additional software tools and thereby provide more accurate ultrasound measurements, as well as forecast whether it will be possible to diagnose scoliosis via ultrasound exclusively. Since we are the first facility in our region that uses ultrasound imaging for the assessment of scoliosis, our next objective will be to focus on further ultrasound software analysis in order to reduce radiation of our patients as much as possible.

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Ethical approval. The Ethics Committee of the Institute for Physical Medicine and Rehabilitation "Dr Miroslav Zotović", Banja Luka, approved the study and informed consent was obtained from all individual respondents. The research was conducted according to the Declaration of Helsinki.

Conflicts of interest. The authors declare no conflict of interest.

References:

1. Negrini S, Donzelli S, Aulisa AG, Czaprowski D, Schreiber S, de Mauroy JC et al. 2016 SOSORT guidelines: orthopaedic and rehabilitation treatment of idiopathic scoliosis during growth. Scoliosis Spinal Disord 2018;13:3.
2. Parent S, Newton PO, Wenger DR. Adolescent idiopathic scoliosis: etiology, anatomy, natural history, and bracing. Instr Course Lect 2005;54:529–36.
3. Weinstein SL, Dolan LA, Spratt KF, Peterson KK, Spoonamore MJ, Ponseti IV. Health and function of patients with untreated idiopathic scoliosis: a 50- year natural history study. JAMA 2003;289(5):559–67.
4. Negrini S, Grivas TB, Kotwicki T, Maruyama T, Rigo M, Weiss HR, et al. Why do we treat adolescent idiopathic scoliosis? What we want to obtain and to avoid for our patients. SOSORT 2005 consensus paper. Scoliosis 2006;1:4.
5. Oakley P, Ehsani ND, Harrison DE. The Scoliosis Quandary: Are Radiation Exposures From Repeated X-Rays Harmful? Dose Response 2019;17(2).
6. Hoffman DA, Lonstein JE, Morin MM, Visscher W, Harris 3rd BS, Boice Jr JD. Breast cancer in women with scoliosis exposed to multiple diagnostic Xrays. J Natl Cancer Inst 1989;81(17):1307–12.
7. Schmitz-Feuerhake I, Pflugbeil S. 'Lifestyle' and cancer rates in former East and West Germany: the possible contribution of diagnostic radiation exposures. Radiat Prot Dosimetry 2011;147(1–2):310–3.

8. Cheung CWJ, Zhou GQ, Law SY, Lai KL, Jiang WW, Zheng YP. Freehand three-dimensional ultrasound system for assessment of scoliosis. J Orthop Translat 2015;3:123–33.
9. Cheung CW, Zhou GQ, Law SY, Mak TM, Lai KL, Zheng YP. Ultrasound Volume Projection Imaging for Assessment of Scoliosis. IEEE Trans Med Imaging 2015;34(8):1760–8.
10. Young M, Hill DL, Zheng R, Lou E. Reliability and accuracy of ultrasound measurements with and without the aid of previous radiographs in adolescent idiopathic scoliosis (AIS). Eur Spine J 2015;24(7):1427–33.
11. Wang Q, Li M, Lou EHM, Wong MS. Reliability and validity study of clinical ultrasound imaging on lateral curvature of adolescent idiopathic scoliosis. PLoS One 2015;10(8):e0135264.
12. He C, Kai-Tsun To M, Pui-Yin Cheung J, Man-Chee Cheung K, Chan CK, Jiang WW, et al. An effective assessment method of spinal flexibility to predict the initialin-orthosis correction on the patients with adolescent idiopathic scoliosis (AIS). PLoS One 2017;12(12):e0190141.
13. Zheng YP, Tin-Yan Lee T, Ka-Lee Lai K, Hon-Kei Yip B, Zhou GQ, Zhou GQ, et al. A reliability and validity study for Scolioscan: a radiation-free scoliosis assessment system using 3D ultrasound imaging. Scoliosis Spinal Disord 2016;11:13.
14. Zmurko MG, Mooney JF, Podeszwa DA, Minster GJ, Mendelow MJ, Guirgues A. Inter- and intraobservervariance of cobbangle measurements with digital radiographs. J Surg Orthop Adv 2003;12(4):208–13.
15. Morrissy RT, Goldsmith GS, Hall EC, Kehl D, Cowie GH. Measurement of the cobb angle on radiographs of patients who have scoliosis. Evaluation of intrinsicerror. J Bone Joint Surg Am 1990;72(3):320–27.
16. Dawson B, Trapp RG. Basic and Clinical Biostatistics. 4th ed. New York: Lange Medical Books/McGraw-Hill; 2004.
17. Schlösser TP, Vincken KL, Rogers K, Castelein RM, Shah SA. Natural sagittal spino-pelvic alignment in boys and girls before, at and after the adolescent growth spurt. Eur Spine J 2015;24(6):1158–67.
18. Brink RC, Wijdicks SPJ, Tromp IN, Schlösser TPC, Kruyt MC, Beek FJA, et al. A reliability and validity study for different coronal angles using ultrasound imaging in adolescent idiopathic scoliosis. Spine J 2018;18(6):979–85.
19. Lee TT, Lai KK, Cheng JC, Castelein RM, Lam TP, Zheng YP. 3D ultrasound imaging provides reliable angle measurement with validity comparable to X-ray in patients with adolescent idiopathic scoliosis. J Orthop Translat 2021;29:51–59.
20. Wong YS, Lai KK, Zheng YP, Wong LL, Ng BK, Hung AL, et al. Is Radiation-Free Ultrasound Accurate for Quantitative Assessment of Spinal Deformity in Idiopathic Scoliosis (IS): A Detailed Analysis With EOS Radiography on 952 Patients. Ultrasound Med Biol 2019;45(11):2866–77.
21. Lai KK, Lee TT, Lee MK, Hui JC, Zheng YP. Validation of Scolioscan Air-Portable Radiation-Free Three-Dimensional Ultrasound Imaging Assessment System for Scoliosis. Sensors (Basel) 2021;21(8):2858.

Poređenje radiografskih i ultrazvučnih mjerenja ugla u procjeni idiopatske skolioze

Samra Pjanić, Goran Talić, Dragana Bojinović-Rodić

Zavod za fizikalnu medicinu i rehabilitaciju „dr Miroslav Zotović“, Banja Luka, Republika Srpska, Bosna i Hercegovina

Uvod. Radiološka dijagnostika i dalje se smatra zlatnim standardnom u detekciji, praćenju i liječenju idiopatske skolioze. Međutim, dokazano je kumulativno i onkogeno djelovanje zračenja. Ultrazvuk kičmenog stuba pomoću Scolioscan® uređaja postaje sve popularniji i pristupačniji širom svijeta s obzirom na to da su relevantna istraživanja pokazala njegov dijagnostički potencijal i primjenu u procjeni i praćenju idiopatske skolioze. Osnovna prednost ultrazvuka u odnosu na standardnu radiografiju je potpuno odsustvo zračenja. Cilj našeg istraživanja je bio da uporedimo mjerenja ugla skoliotične krivine na ultrazvuku i radiografiji kičmenog stuba i da utvrdimo ulogu ultrazvuka za procjenu i praćenje deformiteta kičmenog stuba kod pacijenata sa idiopatskom skoliozom.

Metode. Studija presjeka se sastojala od 172 pacijenta, dječaka i djevojčica, koji su pacijenti Tima za skoliozu na Odjeljenju za habilitaciju i rehabilitaciju djece u Zavodu za fizikalnu medicinu i rehabilitaciju „Dr Miroslav Zotović“ u Banjoj Luci, Republika Srpska. Kod svakog pacijenta urađena je radiografija i ultrazvuk kičmenog stuba istog dana. Tri posebno edukovana tehničara su provodila ultrazvučna skeniranja, a četiri ljekara su mjerila radiografski Cobb-ov ugao i ultrazvučni Scolio ugao. Pacijenti su podijeljeni u grupe prema polu, lokaciji primarne krivine i veličini krivine. Korelacija između Cobb-ovog ugla i Scolio ugla na ukupnom uzorku i prema grupama utvrđena je Pearson-ovim korelacionim testom. Da bi se ispitala statistička značajnost u razlici između varijabli, korišćen je T-test ponovljenih mjerenja ($p<0,05$). Logistička regresiona analiza je urađena da se utvrdi uticaj prediktora (pol, lokacija primarne krivine i veličina krivine).

Rezultati. Ultrazvučni uglovi bili su uopšteno manji u odnosu na Cobb-ove uglove, što je potvrđeno u dosadašnjim studijama. Prosječna razlika između Cobb-ovog i Scolio ugla bila je statistički, ali ne i klinički značajna (3,62 ±4,39°, $p<0,001$). Postoji statistički značajna dobra pozitivna korelacija između Cobb-ovog i Scolio ugla ($r=0,675$, $p<0,001$). Prema grupama, rezultati pokazuju postignutu bolju korelaciju kod djevojčica ($r=0,688$, $p<0,001$), u odnosu na dječake ($r=0,632$, $p<0,001$). Takođe je prisutna bolja korelacija u grupi sa primarnim torakalnim krivinama ($r=0,736$, $p<0,001$) u odnosu na grupu sa (torako) lumbalnim krivinama ($r=0,654$, $p<0,001$). Bolja korelacija se uočava i u grupi sa Cobb-ovim uglom jednakim ili većim od 20° ($r=0,518$, $p<0,05$) u odnosu na grupu sa Cobb-ovim uglom manjim od 20° ($r=0,462$, $p<0,001$).

Zaključak. Rezultati našeg istraživanja su potvrdili dobru valjanost ultrazvučne metode korišćenjem Scolioscan® uređaja u odnosu na standardnu radiografiju, s obzirom na klinički beznačajne razlike u mjerenjima uglova. Korišćenjem samo B-mode opcije na ultrazvuku bez dodatne softverske analize i 3D rekonstrukcije deformiteta kičmenog stuba pokazalo se dovoljnim za praćenje skolioze, ako se uzmu u obzir i drugi parametri (klinička procjena, topografija leđa). Očekuje se da će dalja istraživanja sa upotrebom dodatnih softverskih alata omogućiti preciznija ultrazvučna mjerenja i pokazati da li će se dijagnoza skolioza u budućnosti moći postaviti isključivo ultrazvukom.

Ključne riječi: idiopatska skolioza, ultrazvuk, radiografija