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ORIGINAL ARTICLE

Prevalence, risk of progression and quality of life assessment in adolescents undergoing school screening for adolescent idiopathic scoliosis

Prevalencia, riesgo de progresión y calidad de vida en estudiantes tamizados para escoliosis idiopática adolescente

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What do we know about the subject matter of this study?

Scoliosis is defined as a three-dimensional deformity of the spine and is the most common spinal disorder amongst children and adolescents. 80% of cases are idiopathic(no known cause). The prevalence reported in the literature varies between 2-3%, however, it can range from 0.47 to 5.2% worldwide.

What does this study contribute to what is already known?

This cross-sectional study allows the estimation of the prevalence of Adolescent idiopathic Scoliosis (AIS) measured through tests of high diagnostic reliability and validity. These tests help to diagnose scoliosis with greater accuracy to try and prevent any future consequences of this deformity.

Abstract

Objective: To determine the prevalence of adolescent idiopathic scoliosis (AIS), progression risk, and quality of life in students aged from 10 to 18 years. **Patients and Method:** Cross-sectional descriptive study in students 10 - 18 years old from 5 communes in Santiago, Chile, between 2015-2016. Adam's Test was performed and the angle trunk rotation (ATR) at the thoracic, thoracolumbar, and lumbar levels were measured with a scoliometer. If ATR was ≥ 6°, anteroposterior and lateral radiological images of the spine were taken, and Cobb angle was measured. Scoliosis was confirmed if the Cobb angle was ≥ 10° plus vertebral rotation. Progression factor was calculated with Lonstein and Carlson formula. Quality of life was assessed through spinal deformities questionnaires and the trunk appearance perception scale. **Results:** 1200 students were evaluated, 54.9% were female, and 8.17% had ATR ≥ 6°. We found mild scoliosis in 2.91%, moderate in 0.75% and severe in 0.17%. Total prevalen-

Keywords:
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ce was 3.83% (CI 95%: 2.74 - 4.92). 82.61% of the cases had a late diagnosis, after their growth spurt. Of the patients with scoliosis, 21.74% had a progression risk ≥ 50%. Quality of life had a positive correlation with scoliosis severity, not statistically significant. **Conclusions**. Prevalence of AIS was 3.83%. Most patients were diagnosed after their growth spurt with high progression risk. Quality of life showed a weak positive correlation with scoliosis severity.

Introduction

Scoliosis is defined as a three-dimensional deformity of the spine and is the most common spinal disorder among children and adolescents[1]. 80% of cases are idiopathic and the remaining 20% are secondary to another pathology[2]. The natural history of scoliosis can lead to trunk deformity, pain in adulthood, and respiratory problems in the presence of Cobb curves greater than 90°[3]. It is believed to have a multifactorial origin[1,4,5], occurring more in women[5-8]. It is estimated that about 10% of cases will require conservative treatment and that approximately 0.1-0.3% will require corrective surgery[2].

The most frequent prevalence reported in the literature is 2-3%[3,4,6], however, it can range from 0.47 to 5.2%[1] since it varies around the world, with countries farther away from the equator reporting a higher prevalence compared with countries located closer to it[4].

Observation is a subjective tool frequently used to evaluate the alteration of the trunk caused by Adolescent Idiopathic Scoliosis (AIS), however, the scoliometer is considered an objective and easy-to-use instrument[5,6] capable of measuring the asymmetry of the rib hump. , It has been previously used in many school scoliosis detection programs with good sensitivity[7]. It is recommended that when scoliometer values reach 5° to 7° patients are referred to a surgeon for further tests[11]. Showing more than 10° Cobb angle in a frontal chest radiograph is considered a confirmation of a diagnosis of scoliosis[2].

Lonstein and Carlston created a formula using the Risser sign, which assesses skeletal maturity[12], along with age and curve magnitude[13] to predict the risk of progression (RP) of the curve based on correlation theory. , This theory states that "the younger the child and the larger the curve, the greater the incidence of progression"[8]. The 2011 International Society on Scoliosis Orthopeadic and Rehabilitation Treatment (SOSORT) Guidelines recommended the use of the Lonstein and Carlson progression factor to establish the RP as a prognostic form[2]. However, recent SOSORT guidelines developed in 2016 have pointed out a lack of research evidence verifying the actual accuracy of this formula[14]. Despite the above, the Lonstein and Carlson method is the most widely accepted and used worldwide[9].

Scoliosis is a chronic life long ?condition[10] where problems are related to both physical health and psychological factors associated with quality of life (QoL)[11]. The alteration of the trunk presents a visible cosmetic problem that significantly affects self-image, especially in young people going through adolescence, and this requires considerable adaptation on their part[11,12]. Numerous questionnaires have been developed to measure both the impact that this spinal alteration has on schoolchildren as well as the impact of the treatment itself on the lives of these patients[13,14], Tthe most widely used questionnaires are the QoL Profile for Spine Deformities (QLPSD)[15], the SRS-22[16], the Spinal Appearance Questionnaire (SAQ)[17], and the Trunk Appearance Perception Scale (TAPS)[18].

There is scarce evidence from prevalence studies on this health condition in Africa and South America[24], and Chile is no exception since it only has imprecise estimates[25] and no epidemiological data from any school screening program where the scoliometer was used to detect cases with a suspected diagnosis as recommended by the evidence[11]. However, in 2018, a study was conducted where the thoracic curve was measured only in patients who underwent a chest X-ray for non-spinal reasons and showed a 9.3% prevalence[19].

The objective of this study was to describe the prevalence of scoliosis, RP, and QoL in the population with AIS, aged 10 to 18 years, screened in schools in the Metropolitan Region of Chile.

Patients and Method

The research design of this study was a Cross-sectional descriptive study. Students aged 10 to 18 years from five communes (Peñaflor, El Bosque, Recoleta, Conchalí, and Santiago) of the Metropolitan Region, Chile were included. It should be noted that the sampling method was by convenience since several schools did not accept to participate or did not respond to the invitation to participate. All participants met the inclusion criteria and previously signed an assent or informed consent to participate. In addition, the consent of the parents or legal guardians was requested in the case of children under 18 years of age.

Inclusion and exclusion criteria

Male or female students between 10 and 18 years of age without previous diagnosis of scoliosis. In the case of previously diagnosed students, the Cobb angle measurements were included in the study when the diagnosis was confirmed from a previous radiological examination. Students with non-idiopathic scoliosis (such as neuromuscular scoliosis or any other associated syndrome, etc.) or if they were pregnant were excluded from the study.

Procedure

After obtaining authorization from the relevant school principals, school screening for scoliosis was performed during the school day. The evaluation team was composed of six physical therapists previously trained for the school screening measurement. The Adam's forward bend test was performed in both standing and sitting to ensure that any leg length difference would not affect the scoliosis diagnosis. , In both positions they were asked to lean forward and the angle of trunk rotation (ATR) was measured with a scoliometer at three levels: thoracic (T3 to T11), thoracolumbar (T12 to L1), and lumbar (L1 to L4) in order to detect asymmetries in the spine. If the ATR was ≥ 6°, the participant was referred to a doctor? To perform an anteroposterior (AP) and lateral (including the iliac crest) X-ray. Subsequently, an orthopaedic specialist measured the Cobb angle, the vertebral rotation of the main curve, the Risser's sign, as well as the sagittal curvatures.

For the Cobb angle, scoliosis was considered to be mild when the angle was between 10° and < 20°, moderate between 20° to 40°, and severe ≥ 50°. In the case of the Risser's sign, it has 6 stages described as follows: Risser 0: no ossification center of the iliac crest apophysis; Risser 1: > 25% coverage; Risser 2: 50% coverage; Risser 3: 75% coverage; Risser 4: 100% ossification with no fusion to iliac crest; and for Risser 5: there is complete ossification and fusion of the iliac crest apophysis. These values were used to calculate the curve progression factor based on the Progression factor formula proposed by Lonstein and Carlson (Cobb's Angle - [3 x Risser's sign] / chronological age) where a mild progression factor was considered to be < 20 and < to 40% risk; moderate between 40-60% risk; and severe ≥ 60% risk of progression.

To assess QoL, the QLPSD[20] and the TAPS[18] questionnaires were used. The instruments have not been validated in Chile,but , have been used successfully in other studies[11,21,22].

The QLPSD questionnaire is composed of 21 items in 5 dimensions: 7 related to psychosocial functioning, 4 to sleep disorders, 3 to back pain, 4 to body image, and 3 to spinal mobility. The total score ranges from 21 to 105, where high values are related to a greater impact on QoL[20]. The TAPS includes three sets of drawings corresponding to the three views of the trunk: front, back, and forward bending position. Each drawing is scored from one (worst deformity) to five (no deformity), resulting in a mean score ranging from 1-5[11].

Data analysis

The sample size was estimated from the prevalence of scoliosis reported in the literature (3%), which was based on the sample size calculation formula for proportion, considering a 5% significance level and obtaining 1,200 individuals; this sample of the population was subjected by a proportional allocation, with 134 individuals equally distributed in all ages.

A descriptive analysis of the variables was performed, and the results were reported as absolute frequencies and percentages. The prevalence of scoliosis cases with 95% confidence intervals (95% CI) were calculated. The prevalence was calculated based on the number of confirmed cases of scoliosis divided by the total population of this study. A diagnosis of scoliosis was confirmed when the measured Cobb angle was ≥ 10° and with the presence of vertebral rotation. This procedure was performed according to the Scoliosis Research Society diagnostic criteria standard; the risk of curve progression was calculated by the formula (Cobb angle - [3 x Risser's sign]/chronological age). The QoL data analysis for the QLPSD and TAPS questionnaires was performed using Spearman's correlation coefficient analysis. This coefficient can score values between +1 and -1, where +1 at means a perfect rank association, 0 that there is no rank association, and -1 a perfect negative association between ranks. If the value is close to 0, the association between the two ranks is weaker. The data were analyzed using the STATA 14.0 statistical package. The study was approved by the Ethics Committee of the *Universidad de los Andes*, Santiago, Chile.

Results

1200 students were evaluated, 54.92% (659) were female and 45.08% (541) were male. When measuring with a scoliometer, 8.17% (98) of the students presented with an ATR ≥ 6 ° and were referred for radiography. Of the 98 students detected, 22 were unable to show up for various reasons.

In addition, 4 students were detected who did not want to undergo scoliometer measurement because they claimed to have severe scoliosis (1 with corrective surgery and 3 who were waiting for surgery), a situation that could not be corroborated since they did not show their X-rays. Therefore, they were not considered for the final prevalence count (Figure 1).

Once the X-ray results were obtained and after measuring the Cobb angle, we found 43 students with a confirmed scoliosis, plus 3 female students who had a previous diagnosis (confirmed by measuring the Cobb angle in their X-rays), resulting in 46 cases, equivalent to a final prevalence rate of 3.83% (95% CI: 2.74 - 4.92) (Figure 1).

12 participants reported having previous scoliosis, but we did not have access to their X-rays to measure the Cobb angle and confirm this. If these individuals had confirmed the diagnosis of scoliosis, the prevalence would have been 4.83% (95% CI: 4.55 - 5.11).

Mild scoliosis was found in 2.91% (35) of the population examined (22 females and 13 males); moderate scoliosis in 0.75% (9) of the total number of students (8 females and 1 male); and two students had severe scoliosis, equivalent to 0.17% of the sample (Figure 2a). The most common scoliosis pattern was a single left thoracolumbar curve. Figure 2b shows the distribution of the remaining patterns.

In addition, there were school children with a spinal curvature with a Cobb angle of 10°, but two students with ATR ≥ 6° did not present with associated vertebral rotation, and also there were 9 students with curves of less than 10° with ATR ≥ 6°, where 4 of them had a difference in leg length showing functional scoliosis and the remaining 5 had double rib contour sign with Risser 0 at the age of 10-11 years.

According to the time of detection of the scoliosis diagnosis, two groups were identified: Group 1 corresponding to early diagnosis when the growth spurt was in progress (between 10 to 11 years in females and 13 to 14 years in males) and Group 2 corresponding to late diagnosis when the students had passed the growth spurt (being older than 12 years in females and older than 14 years in males). Group 1 comprised 17.39% of the total sample (8 out of 46) of the students and Group 2 comprised 82.61% (38 out of 46).

According to the Lonstein and Carlson formula, 21.74% (10 of 46) of the scoliosis cases had a Risk of Curve Progression ≥ 50%, and Group 2 had the highest concentration of students with this characteristic.

Of the 46 confirmed cases, only 30 completed the TAPS and QLPSD questionnaires, of which 27 had mild scoliosis, 2 had moderate scoliosis, and 1 had severe scoliosis. It was observed that all showed an effect? on their QoL to some degree, however, no significant correlation was observed between the severity of the curve (Spearman correlation coefficient = 0.31; p > 0.05), showing in the QLPSD scores ranging from 26 to 83, with a median of 58 points, and the student who obtained the highest score (with the greatest effect on QoL) had mild scoliosis. Besides, the TAPS results showed that, in the 3 sets of drawings evaluated, the third image was the most frequent choice for students with mild scoliosis, which was the one that presented a good perception of their condition; the students with moderate scoliosis (n = 2) chose the second image which showed a fair perception of themselves; and the student with severe scoliosis showed greater variability in the responses, which ranged from a Fair, Good, and Very good perception for the posterior view of the back, the magnitude of the rib hump, and the anterior view, respectively.

Discussion

The prevalence value of AIS in this study (close to 4%) is similar but higher than the values reported in the literature[3,4,23]. Therefore, the theory suggested by Grivas et al. (2006)[23], which establishes a higher prevalence value in countries far from the equator, also seems to apply to Chile, which is in the southern region of the world.

A hypothetical descriptive analysis assumed that all 12 students had a positive diagnosis of scoliosis, which showed a 1% increase in prevalence. However, more complex statistical analysis techniques (data imputation and sensitivity analysis, among others) are required and were not the objective of this study.

This study found a significant number of students who were first diagnosed after going through the pubertal growth spurt (82.61% of scoliosis cases from Group 2), which means that this late diagnosis could lead to lower effectiveness of conservative scoliosis treatment opportunities due to the skeletal maturity reached during this period[3,24,] especially in those cases where students with moderate and severe scoliosis were detected.

The use of the scoliometer suggests that it is an objective and effective tool in the detection of scoliosis in schoolchildren when the curve is still small enough (asymptomatic) to benefit from conservative treatment (either physiotherapeutic scoliosis-specific exercises [PSSE] or bracing)[25] since it was able to diagnose early 17.39% of the schoolchildren aged 10 to 11 years from the Group 1, where more than half of these students had a high risk of curve progression (≥ 50%). This fact is interesting since the National Scoliosis Detection Program run by JUNAEB only uses observation to refer cases with suspected scoliosis and the screening is performed in seventh grade[25], when teenagers are 12 years old and when girls are going through their pubertal growth spurt (33).

It is known that the most common scoliosis pattern found in the literature is a thoracic curve[1], however, this study showed that the thoracolumbar pattern of left convexity was the most frequently observed in this population. This may be a result of the diversity of ethnicities that express scoliosis differently[1].

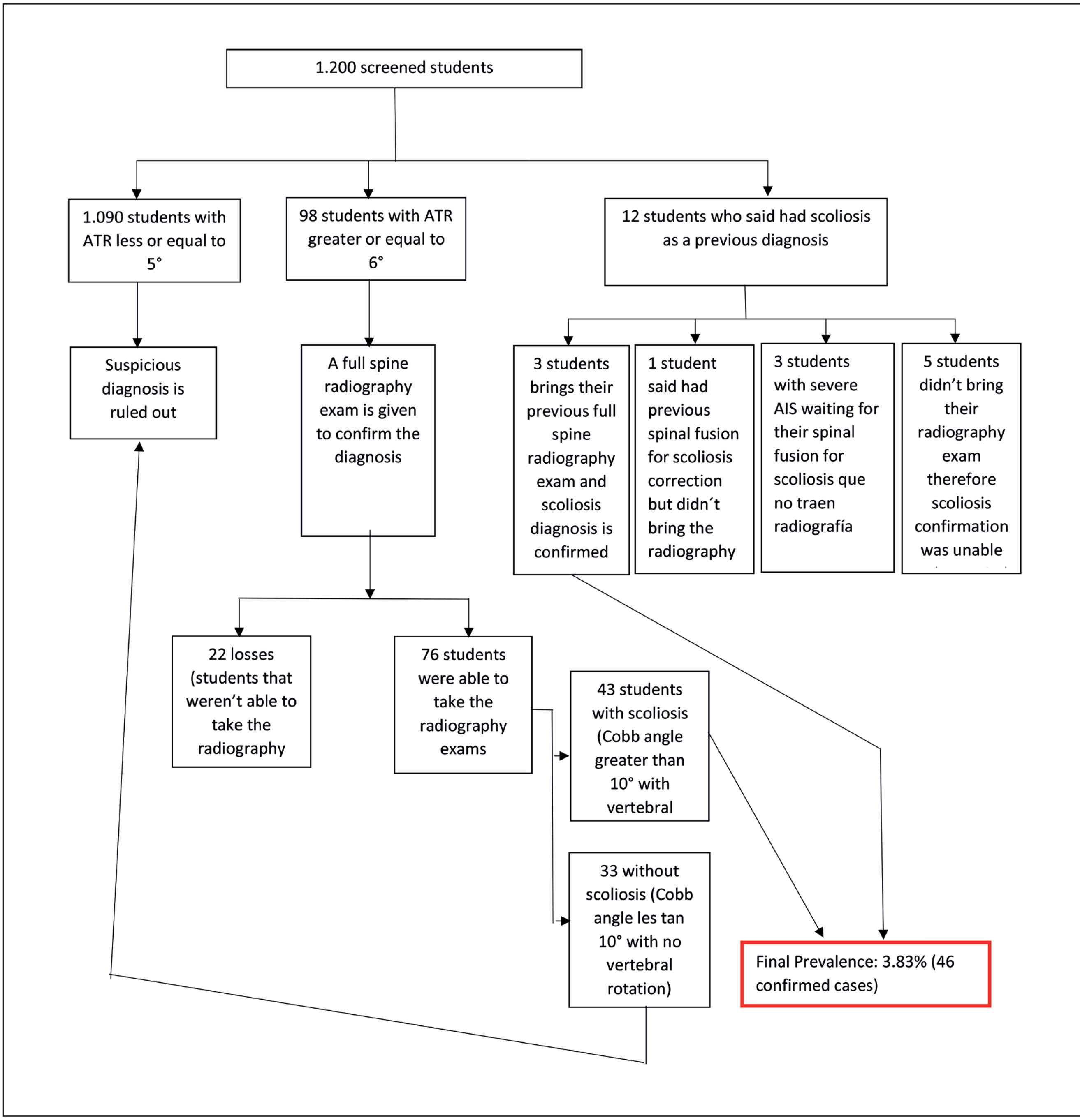

Figure 1. Flowchart – Screening outcomes

Curve severity	Total	Percentaje (%)	Females	Males
Mild escoliosis	35	2.91	22	13
Moderate scoliosis	9	0.75	8	1
Severe scoliosis	2	0.17	2	0
Total	46	3.83	30	16

Figure 2a. Curve severity distribution

QoL is an important component to evaluate specifically according to the patient[26]. In this study, although the results found were not significant, a positive and low correlation was observed, which could be a hypothesis to be evaluated in future research. In addition, it was possible to apply two specific instruments for scoliosis, allowing to have results focused on this pathology[21], however, a future study is necessary to validate these tools in the Chilean population.

The results of this study provide findings regarding the prevalence of scoliosis as well as the real magnitude of the AIS health problem in Chile. Likewise, the results also suggest that the information provided in the Chilean Scoliosis Guidelines, as well as the Chilean public health policies regarding public awareness and screening for scoliosis, could be updated, where it is necessary for the National Scoliosis Screening Program to consider screening with the use of a scoliometer, especially in the pubertal growth spurt where the risk of curve progression is high[27] and where early intervention with PSSE and bracing is most effective[24]. However, there is a lack of research in this area to answer questions that are still unanswered.

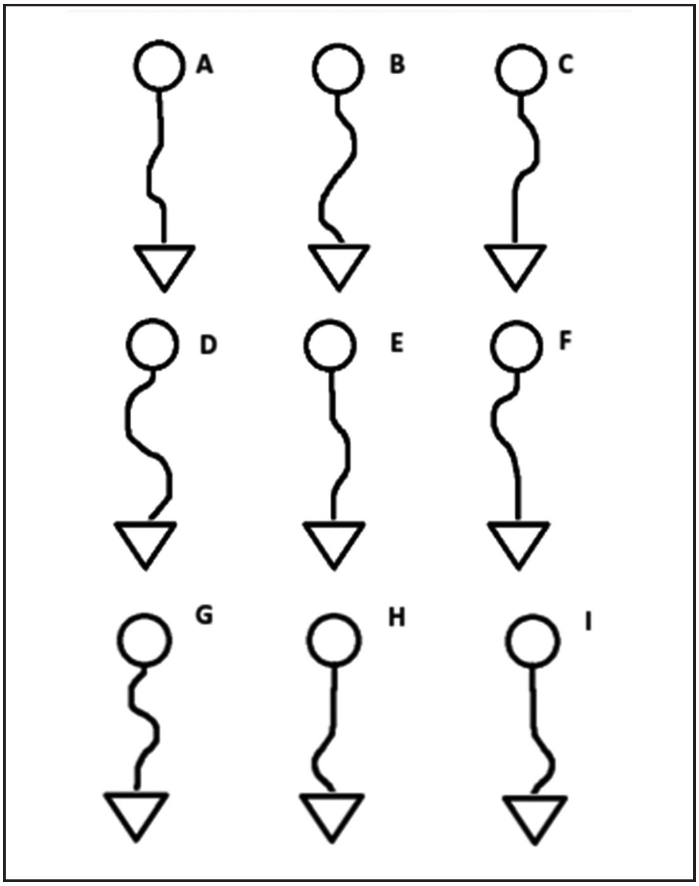

Figure 2b. Scoliosis pattern frequency distribution. A single left thoracolumbar curve (**A**) was found to be the most frequent pattern among 16 students corresponding to 34.78% of the confirmed cases; followed by 11 cases with a double mayor curve with a right thoracic and left lumbar curve (**B**) corresponding to 23.91% of the scoliosis cases. Then, a single right thoracic curve (**C**) was found in 5 students, representing a 10.87%; and a double mayor curve with a left thoracic and right lumbar curve (**D**) and a single right thoracolumbar curve (**E**) were observed in 4 students in each pattern representing the 8.69% each; followed by a single left thoracic curve (**F**) and a double mayor curve with a left thoracic and a right thoracolumbar curve (**G**) that were observed in 2 students in each pattern (representing a 4.34% in each patterns); and finally, 1 student was observed to have a single left lumbar curve (**H**) and also, 1 student had a single right lumbar curve (**I**), these last two having the 2.17% of the total.

Ethical Responsibilities

Human Beings and animals protection: Disclosure the authors state that the procedures were followed according to the Declaration of Helsinki and the World Medical Association regarding human experimentation developed for the medical community.

Data confidentiality: The authors state that they have followed the protocols of their Center and Local regulations on the publication of patient data.

Rights to privacy and informed consent: The authors have obtained the informed consent of the patients and/or subjects referred to in the article. This document is in the possession of the correspondence author.

Conflicts of Interest

Authors declare no conflict of interest regarding the present study.

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