Occlusal deviations in adolescents with idiopathic and congenital scoliosis

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Abstract

Objective The objective of this cross-section study was to investigate by clinical examinations the characteristics of malocclusions in scoliotic patients.

Methods Fifty-eight patients with idiopathic scoliosis (IS) and 48 patients with congenital scoliosis (CS) participated in the study. A random group of 152 orthopedically healthy children served as the control group. Standardized orthodontic and orthopedic examination protocols were used to record the occlusal patterns and type of scoliosis. Assessments were made by three experienced orthodontists and a spinal surgery team. Statistical differences in the occlusal patterns frequency of distribution was evaluated by the chi-squared test.

Results CS patients had a higher incidence of Cobb angle ≥ 45° ($P = 0.020$) and included a higher proportion of surgical treatments ($P < 0.001$) compared with IS patients. Distribution of the Angle Class II subgroup was significantly higher in IS ($P < 0.001$) and CS ($P = 0.031$) groups compared to the control group. Compared to healthy controls, there were significantly higher ($P < 0.05$) frequencies of asymmetric molar and asymmetric canine relationships, upper and lower middle line deviations, anterior deep overbite, unilateral posterior crossbite and canted occlusal plane, especially in CS patients but also to a lesser extent in IS patients.

Conclusions Scoliotic patients had high frequencies of malocclusions, which were most obvious in patients with CS.

Key words: facial asymmetry; dentofacial anomalies; scoliosis; malocclusion

Introduction

Scoliosis is a three-dimensional deviation of the spinal axis and an orthopedic condition characterized by postural abnormalities[1-2], with the most common type in adolescents in China being idiopathic scoliosis (IS)[3]. In previous literature, the possible relationship between abnormal body posture and disorders in the oral and maxillofacial systems have been investigated[4-5].

Hitchcock conducted a case study to provide evidence for a possible causal relationship between occlusion and scoliosis[6]. Motoyoshi et al. confirmed that the distribution of occlusal stress might be related to the change of head and neck posture using finite element analysis[7]. A study of scoliosis and spinal deformities suggests that patients with a spinal deformity develop a high incidence of temporomandibular disorder, Angle Class II malocclusion, deep overbite and deep overjet[8]. Lippold et al. found that Angle Class II malocclusion had a higher incidence in preschool children with scoliosis[9]. A subsequent literature review confirmed the increased prevalence of malocclusions in children affected by scoliosis[10]. The observation that the masticatory system and the body posture regulating system are anatomically and functionally related, have led to several hypotheses of correlations between occlusion and postural disturbances[11]. Patients with IS always manifest a coronal curvature of the spine and grow progressively curved[12]. While the majority of IS manifested itself in adolescence[13], early onset scoliosis cases develop before adolescence and is categorized as a subclass of IS as a developmental disorder of malformation or faulty segmentation of the vertebrae, and often occurs in combination with other abnormalities[14-15].

Recent studies are mostly cross-sectional research that focused on the morphological and functional abnormalities of the stomatognathic system in patients with IS[16-17]. However, dental-occlusal features in patients with CS were rarely reported. Therefore, in the present study we included idiopathic and CS cases. We hypothesized, that compared with healthy children, IS and CS patients might have different patterns of malocclusions.

Material and Methods

Patients

All patients involved in this cross sectional study received detailed information on orthodontic and orthopedic examinations beforehand. They (or their guardians) provided written consent to participate in the study. The examinations complied with the requirements set by the Ethics Committee of the Seventh Medical Center of PLA General Hospital.

The study involved patients who were diagnosed with scoliosis from April 2013 to April 2018. Patients underwent clinical examinations by spinal surgeons and orthodontists, who took radiographic images of the entire spine and CT images for further diagnoses. Twenty patients were excluded because of a history of orthodontic treatment, cleft lip and palate, maxillofacial fracture, trauma, infection or because of severe dental crowding. Healthy volunteers were recruited from the local junior and senior middles schools as the control group under the following selection criteria: natural complete dentition; orthopedically healthy; no history of orthodontic treatment; no maxillofacial deformities. The incidence of malocclusion patterns is indicated as a frequency or percentage.

Orthodontic examination

The occlusion variables examination for each individual was taken by three orthodontists. The orthodontists accepted training in advance and their experience was > 5 years to ensure the accuracy of examination results. If there were some inconsistencies in the dental examination, the majority would

be determined as the final records, or a case discussion would be conducted to reach an agreement, in order to address potential sources of bias.

The following issues were considered and the data recorded:

(1) Dentition development stage: primary dentition, transitional dentition, permanent dentition;
(2) Sagittal dimension: canine relationship, molar relationship and Angle's classification comprising Class I occlusion referring to a centric occlusion in which the mesio-buccal cusp of the upper first molar occludes the buccal groove of the lower first molar, Class II occlusion referring to a retrognathic positional relationship in which the mesio-buccal cusp of the upper first molar occludes anterior to the mesial buccal groove of the lower first molar. The Angle Class II subgroup refers to cases with Angle Class II on one side and Angle Class I or III on the other side. Angle Class III occlusion refers to a prognathic positional relationship in which the mesio-buccal cusp of the upper first molar occludes posterior to the buccal groove of the lower first molar;
(3) Transverse dimension: upper midline deviation, lower midline deviation, posterior crossbite;
(4) Vertical dimension: occlusal plane inclination, anterior and posterior over bite;
(5) Other estimations: spacing, crowding, teeth losses, oral habits, or caries may influence inter-arch relationships.

Orthopedic examination

Orthopedic examinations and diagnoses were taken by the spinal surgeon team according to physical examination, X-ray of spine and medical history. The following parameters were determined primarily in this epidemiological study.

(1) Type of scoliosis. The patient was diagnosed by orthopedists with IS or CS according to the full-length anteroposterior and lateral X-ray spine images, CT 3-dimensional spine reconstructions and clinical manifestations. In addition the medical history was evaluated as to when patients developed symptoms, were diagnosed at birth or before their preschool stage (CS cases) or whether patients developed symptoms and were diagnosed in the preadolescent period (IS cases). Patients diagnosed with neuromuscular scoliosis or Scheuermann's disease and conditions other than IS and CS were excluded.

(2) Cobb angles were determined with the upper/lower end vertebras on the full-length spine anteroposterior X-ray films. Generally, if the Cobb angle is < 45°, brace therapy should be used, but surgical treatment is recommended if Cobb angles are > 45°[18-19].

Statistical analysis

All data were analyzed using SPSS ver. 18.0 (IBM, Armonk, NY, USA).The incidence of malocclusion patterns in IS, CS and control groups were compared using the chi-squared test (test level $P = 0.05$).

Results

Basic characteristics and severity distribution in patients with scoliosis

A total of 106 patients with scoliosis, including 58 patients with IS and 48 patients with CS participated in this study. There were 87.9% and 60.4% females in the IS and CS groups. The mean ages of patients during the study were 14 years and 8 months in the IS group and 15 years and 3 months in the CS group. Severity was significantly higher in the CS patients reflecting a greater surgical treatment rate (**Table 1)**. A total of 152 healthy volunteers (mean age 15 years and 2 months

(range: 12 years and 2 months to 18 years and 6 months) served as the controls.

Angle classification in patients with scoliosis

Individual normal occlusion and Class I malocclusion distribution ratio in CS group was 47.9%, which was significantly lower than that in the control group ($P < 0.05$), but no statistical difference was found between IS group and control group. However, Class II subdivision distribution ratio was significantly higher in both the IS (17.24%) and CS (29.2%) groups in the control group (7.2%) ($P < 0.05$) (***Table 2***).

The high proportion of the Class II subdivision indicated sagittal asymmetry of bilateral occlusion in patients with scoliosis.

Occlusion patterns in patients with scoliosis (Table 3)

In the sagittal dimension, the asymmetry incidence of molar relationship (29.2%) and canine relationship (29.8%) was significantly higher in the CS group ($P < 0.05$). And the proportion of asymmetric molar relationships in the IS group was 17.2%, which was significantly higher than that (7.89%) in the control group. There were 2 cases in the IS group, 1 case in the CS group and 4 cases in the control group that were excluded from the statistic data of canine relationships, because the orthodontists were unable to take an accurate record due to embedded or lost canines.

In the transverse dimension, the incidence of lower midline deviation in the IS and CS groups was 39.7% and 45.8% respectively, and they were both higher than the value of 25.6% found in the control group ($P < 0.05$). In contrast, a significant difference in the proportion of upper midline deviations was found between the CS group and the control group only ($P = 0.034$). The incidence of upper midline deviations in the IS group was 25.9% compared to 17.1% in the control group ($P = 0.152$). And unilateral posterior crossbite was more frequent in both the IS (15.5%, $P = 0.034$) and CS (27.1%, $P = 0.001$) groups compared to the control group (8.55%).

In the vertical dimension, a canted occlusal plane was present in both the IS (20.9%, $P = 0.036$) and CS (27.1%, $P = 0.003$) groups in a greater proportion compared to the control group (9.9%). Anterior deep overbite presented more frequently in the CS group, but no significance difference was found between the IS and control groups.

Figure 1 shows the X-ray and dental images of an 18-years old female patient with severe CS, whose thoracic spine was severely deformed and twisted. The patient also developed a unilateral (right side) Angle Class II subgroup occlusion.

Discussion

In this study, gender and severity distributions were similar to previous reports[15,20]. The Class II subdivision distribution ratio was significantly higher in both the IS and CS groups compared to the control group, indicating sagittal asymmetry of bilateral occlusion in patients with scoliosis (**Table 2**).

Seven parameters [21]were applied to represent the asymmetric occlusal patterns in 3-**dimensions** in this research. The incidence of all these asymmetric occlusal patterns was significantly higher in the CS group compared to the control group. In the IS group, incidences of these asymmetric occlusal patterns were statistically higher, except the canine relationship, upper middle line deviation and deep overbite,

which indicated to some extent idiopathic patients suffered less occlusal asymmetric deformity compared to patients with CS. These findings were presumably related to minor spinal deformity and a shorter course of IS. And another possibility contributing to these findings was that not sufficient numbers of cases were involved in the study.

Investigators have reached a consensus that bilateral asymmetries are a common feature of occlusions[16,17,21]. However, opinions about the etiology of occlusal asymmetries differ. Cross-sectional research, by Lewandowska[16], confirmed bilateral dentoalveolar asymmetries in patients with adolescent IS. Nevertheless, another IS study[17] found a functional lateral mandibular displacement in two individuals. At present, methods to evaluate dental/facial asymmetric features of scoliotic patients are clinic dental examination, measurements of full-mouth dental casts or posterior-anterior **cephalograms.** The authors believe that further studies should focus on 3-**dimensional** asymmetry of the maxillofacial skeleton, as its growth and developmental tendency vary with the progress of scoliosis. In order to investigate the changes of malocclusion degree with age in patients with scoliosis, Subjects should be divided into groups by age in the future research.

Several authors have tried to establish any possible connection between the location, direction or severity of scoliosis and dental facial anomalies. One study demonstrated a correlation between the left proximal thoracic curve of scoliosis and the anterior partial open bite[17]. Another study on mandibular deviation patients also confirmed that the mandibular deviation direction was the same as the lateral bending of the thoracolumbar vertebrae, which was opposite to the lateral bending of the cervical vertebrae[22]. However, hypotheses on the correlationship between scoliosis and occlusion have varied in recent decades [10,23-26]. This correlation was assumed to be based on the anatomic and functional connection between the stomatognathic complex and the cervical vertebra. Anatomic connection referred to the muscular and ligament attachments between the craniofacial complex and the cervical vertebra. A functional connection among the cranium, mandible, and cervical vertebra was adjusted by visual balance and a gravity effect. Muscular balance between the neck and masticatory system has been demonstrated to have an essential role in the relationship between asymmetric malocclusion and scoliosis[27-28]. Kondo et al. found that early improvement in occlusion, combined with physiotherapy to achieve muscular balance of the neck and masticatory system, was effective for improvement of muscular function asymmetry[29]. Early correction of muscular torticollis should be considered to prevent progression of facial asymmetry in congenital muscular torticollis patients [30]. All these findings indicate that there indeed may be an interaction effect between the masticatory system and body posture.

However, there are a number limitations to this study. Sixteen adolescents with scoliosis were excluded because of severe crowding, nevertheless, mild crowding has a potential influence on occlusal patterns, which could contribute a **systematic error.** Although the exclusion of orthodontic patients with scoliosis may introduce bias to the results. The conclusion remains reliable, given the excluded number of scoliotic patients was only two in this study.

Conclusions

The results of this cross-sectional study partially confirmed the findings of previous research that reported a higher frequency of dentofacial **deviations** in adolescents with various orthopedic problems. In both the IS and CS groups, significant differences were found in the severity and frequency of asymmetric occlusions compared to controls. In addition, more severe dentofacial deviations were observed in CS compared to IS patients, which indicated that asymmetric malocclusions in adolescents

may remind both parents and medical staff about the need for the early detection and treatment of potential orthopedic problems.

Conflicts of interest statement

The authors declare no conflict of interest.

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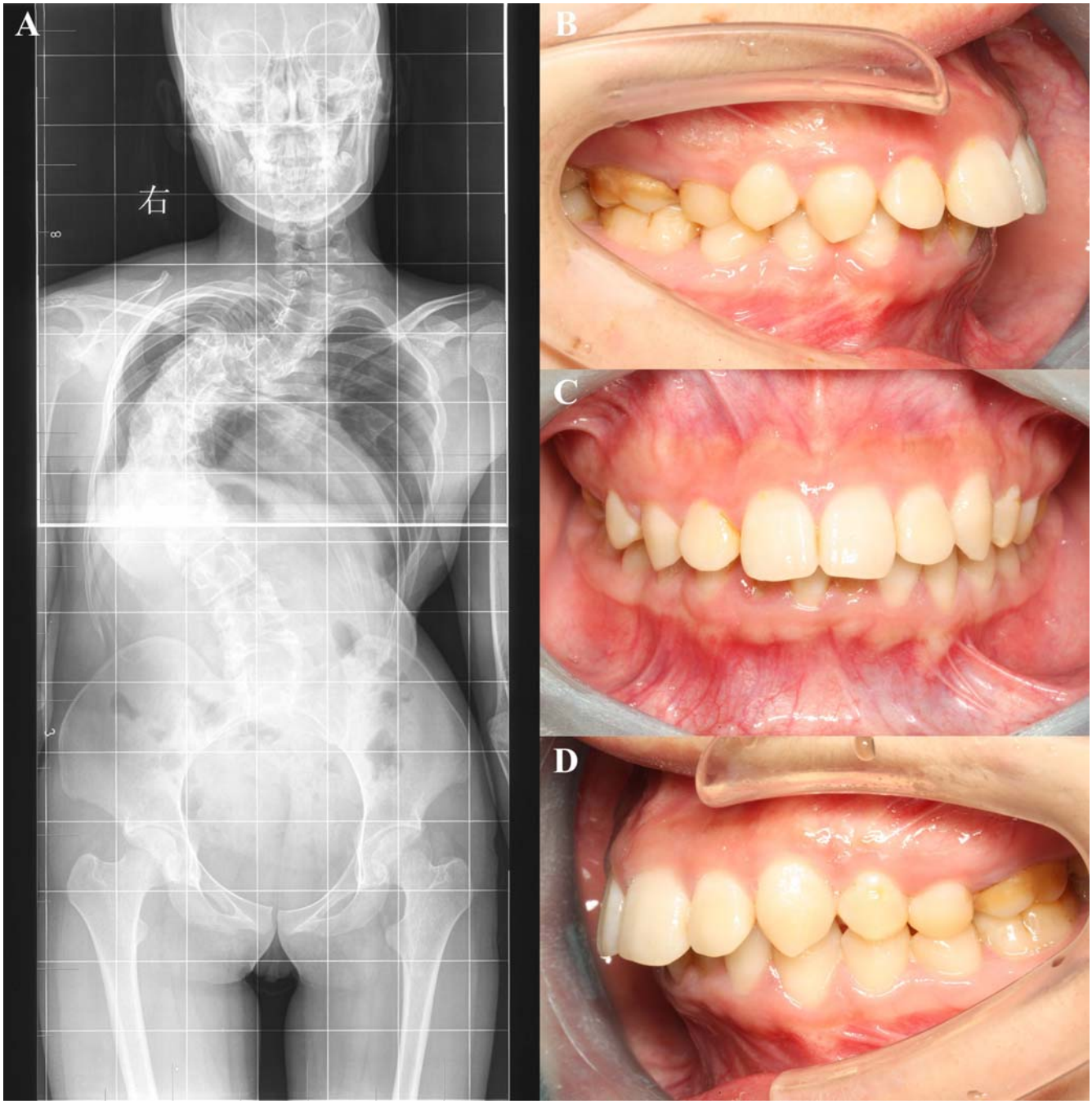

Figure 1. X-ray and dental images of an 18-years old female patient with congenital scoliosis and an Angle Class II subgroup classification

A) Full-length anteroposterior X-ray spine image showing a severely deformed and twisted spine; B) dental image showing a mandibular deviation on the right jaw; C) dental image showing an oblique occlusal plane; D) dental image showing a normal mandibular occlusion on the left jaw.

Table 1. Gender distribution, age, severity distribution and treatment method distribution in patients with scoliosis

	IS group (n = 58)	CS group (n = 48)	*P*-value
Gender distribution, n (%)			0.001
Male	7 (12.1)	19 (39.6)	
Female	51 (87.9)	29 (60.4)	
Age			-
Mean	14Y8M	15Y3M	
Min-Max	12Y4M-20Y2M	10Y5M-23Y6M	
Severity distribution, n (%)			0.020
Cobb angle ≥ 45°	22 (37.9)	31 (64.6)	
Cobb angle < 45°	36 (62.1)	19 (35.4)	
Treatment method distribution, n (%)			< 0.001
Surgical treatment	20 (34.5)	42 (87.5)	
Physical therapy	38 (65.5)	6 (12.5)	

Note: IS group: idiopathic scoliosis group; CS group: congenital scoliosis group.

Table 2. Distribution of angle classification in the idiopathic scoliosis, congenital scoliosis and control groups

Angle classification	IS group (n = 58)		CS group (n = 48)		Control group (n = 152)		*P*-value (IS *vs* control)	*P*-value (CS *vs* control)	*P*-value (IS *vs* CS)
	n	%	n	%	n	%			
Normocclusion and Class I	35	58.6	22	47.9	103	67.8	0.311	0.006	0.136
Class II	13	22.4	10	20.8	24	15.8	0.260	0.417	1.000
Class II subgroup	10	17.2	14	29.2	11	7.2	0.031	< 0.001	0.144
Class III	1	1.7	2	4.1	14	9.2	0.060	0.261	0.450

Note: IS group: idiopathic scoliosis group; CS group: congenital scoliosis group

Table 3. Occlusal patterns of idiopathic scoliosis, congenital scoliosis and control groups

Occlusal patterns	IS group (n = 58)		CS group (n = 48)		Control group (n = 152)		*P*-value (IS group *vs* control)	*P*-value (CS group *vs* control)	*P*-value (IS *vs* CS)
	n	%	n	%	n	%			
Asymmetric molar relationship	10	17.2	14	29.2	12	7.9	0.048	< 0.001	0.144
Asymmetric canine relationship	11 (56)	19.6	14 (47)	29.8	14 (148)	9.5	0.094	0.001	0.232
Deviation of upper middle line	15	25.9	15	31.3	26	17.1	0.152	0.034	0.540
Deviation of lower middle line	23	39.7	22	45.8	39	25.6	0.047	0.008	0.522
Anterior deep overbite	21	36.2	19	39.6	36	23.7	0.068	0.003	0.721
Unilateral posterior crossbite	11	15.5	13	27.1	13	8.6	0.034	0.001	0.320
Canted occlusal plane	12	20.9	13	27.1	15	9.9	0.036	0.003	0.440

Note: IS group- idiopathic scoliosis group; CS group- congenital scoliosis group.