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A GREAT MIMICKER OF ADOLESCENT IDIOPATHIC SCOLIOSIS: SCIATIC SCOLIOSIS. A RETROSPECTIVE REVIEW OF 18 ADOLESCENT PATIENTS WITH AT LEAST 2 YEARS OF FOLLOW-UP

Yiğit Erdağ[1], Tuna Pehlivanoğlu[2]

[1]EMSEY Hospital, Department of Orthopedic Surgery and Traumatology, Advanced Spine Surgery Center, İstanbul, Turkey
[2]Liv Hospital Ulus, Department of Orthopedic Surgery and Traumatology, Liv Spine Center, İstanbul, Turkey

ABSTRACT

Objective: Sciatic scoliosis (SS) induced by lumbar disc herniation (LDH) is a great mimicked of adolescent idiopathic scoliosis (AIS). This study aimed to evaluate the clinical-radiographic presentation of SS in adolescents caused by LDH, while reporting on the average 3 years results of lumbar microdiscectomy in terms of radiographic and functional outcomes.

Materials and Methods: Eighteen adolescent patients who presenting for evaluating SS with radiculopathy were enrolled. They had an average age/follow-up duration of 17.1 years/36.8 months. Lumbar microdiscectomy was applied to them. Radiographic measurements, including the analysis of curve pattern, major curve magnitude and coronal balance were undertaken.

Results: A short lumbosacral curve combined with an opposite sided long thoracic and/or thoracolumbar curve was detected. 16/18 patients were detected to have LDH at the convex side of the lumbosacral curve. 14/18 were detected to have a trunk shift directed to the opposite side of the LDH. Average major curve magnitudes pre-op and at the last follow-up (FU) visit were 25.1°/4.2° respectively (p=0.001). Patients had an average pre-operative coronal imbalance of 4.1 cm reduced to 1.3 cm at the last FU (p=0.003). Average visual analogue scale leg-back and Oswestry Disability Index scores improved from 7.1-4.2 and 36.1% pre-operatively to 1.3-0.7 and 6.2% at the last FU (p<0.001). SF-36 scores were detected to be improved with high statistical significance at the last FU.

Conclusion: SS was associated with short lumbosacral curves accompanied by long thoracic and/or thoracolumbar curves, while the LDH was often located at the convex side. In adolescent cases, microdiscectomy could yield an immediate recovery of the radicular pain in addition to excellent functional outcomes, while successfully restoring the coronal balance in the long term follow-up.

Keywords: Scoliosis, lumbar disc herniation, lumbar microdiscectomy, trunk shift, non-structural curve, coronal imbalance, resolution

INTRODUCTION

Lumbar disc herniation (LDH) was reported to result in sciatic scoliosis (SS), which was defined as a non-structural curve secondary to nerve root compression[1-3]. While the association between LDH and non-structural/SS was clearly defined, the pathophysiology and significance were not clarified[4-7]. It was repeatedly reported, that the SS was a compensatory postural adjustment of the patient to relieve the nerve irritation[1,3,8]. Hence, in conjunction with the non-structural nature of the SS, an improvement of the deformity and trunk list was expected if the pain generating pathology -the herniated disc- was removed[3,7]. Lumbar (open/endo-/micro) discectomy was advised as the ideal treatment option for LDH associated with SS in adolescents, while improvement of the non-structural curve as a result of discectomy was reported as well[1,6,9]. LDH was seldomly reported in adolescents with the incidence up to 5% with genetic predisposition and trauma being reported as the predisposing factors[10-12]. SS caused by LDH in adolescent patients, could easly be mistaken for adolescent idiopathic scoliosis (AIS) which rarely causes pain resulting in the delay of the definitive treatment and increasing the risk for residual deformity and pain[3,8,13]. Besides, unlike the adults, scoliotic list could be the initial symptom of LDH in adolescents, because of the superior adaptive capacity of pediatric spine to protect the neural structures by performing lateral flexion[2,6,8]. The aim of the present study to evaluate the clinical and radiographic presentation of SS in adolescents caused by LDH, while reporting on the average 5 years results of microdiscectomy in terms of the coronal balance and functional outcomes. It was questioned, whether the SS was associated with a certain type of curve and certain side of the herniated disc related to that curve.

Address for Correspondence: Tuna Pehlivanoğlu, Liv Hospital Ulus, Department of Orthopedic Surgery and Traumatology, Liv Spine Center, İstanbul, Turkey
Phone: +90 533 393 66 00 **E-mail:** dr.tuna@hotmail.com **Received:** 13.08.2022 **Accepted:** 06.09.2022
ORCID ID: orcid.org/0000-0001-8886-7538

MATERIALS AND METHODS

After obtaining Institutional Review Board of EMSEY Hospital (approval date: 02/02/2021, approval no: 1121077) approval, a retrospective analysis was undertaken to detect a consecutive group of patients with SS and LDH operated in a single institution between 2018 and 2020 with lumbar microdiscectomy technique. One hundred fifty four consecutive patients were detected. Patients were enrolled in the present study on the basis of the following inclusion criteria: (1) Being adolescent (age 10-18); (2) having a magnetic resonance imaging (MRI) confirmed diagnosis of LDH; (3) having been operated with lumbar microdiscectomy technique, (4) having a documented negative Adam's forward bending test (indicating a non-structural curve); (5) having a minimum follow-up (FU) period of 2 years; (6) being willing to participate in the study Table 1. Exclusion criteria comprised: (1) Being adult (age >18); (2) having no pre-operative MRI in the picture archive and communication system (PACS); (3) having been operated with open lumbar discectomy technique, (4) having a history of spinal infection-tumor; (5) having a concomitant diagnosis of AIS or positive Adam's forward bending test Table 1. As a result of the exclusion criteria 136 patients were excluded from the study (127: adults; 4: having a concomitant diagnosis of AIS-positive Adam's forward bending test; 2: has an history of spinal tumor, 2: has an history of spinal infection; 1: no MRI in PACS system) Table 2.

Radiographic Outcome Parameters (ROP)

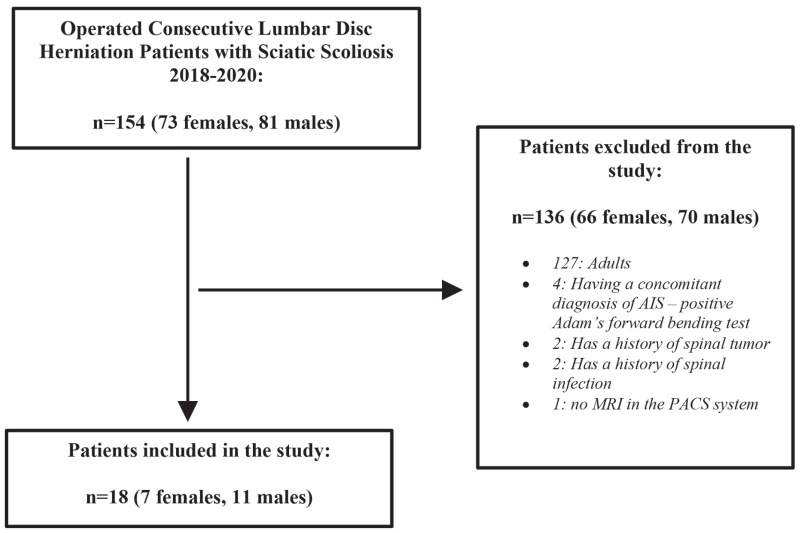
Pre-operative and post-operative radiographic measurements were undertaken on standing whole spine X-rays. The radiographic examination protocol was standardized for all patients. ROP was composed of the major curve magnitude in the coronal plane measured by using the Cobb angle, and coronal balance by using central sacral vertical line [(CSVL) to C7-plumb line (C7PL) distance]. MRI was used to confirm the level and side of LDH. All patients had pre-operative MRI, while AIS cases were also reviewed by the radiologist regarding a history of conservatively treated LDH. The radiographic measurements were undertaken by one independent spine surgeon with Surgimap software (Nemaris

Table 1. Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Being adolescent (age 10-18)	Being adult (age >18)
Having a MRI confirmed diagnosis of LDH	Having no pre-operative MRI in the PACS
Having been operated with lumbar microdiscectomy technique	Having been operated with open lumbar discectomy technique
Having a documented negative Adam's forward bending test (indicating a non-structural curve)	Having a history of spinal infection-tumor
Having a minimum follow-up period of 2 years	Having a concomitant diagnosis of AIS or positive Adam's forward bending test.
Being willing to participate in the study	Being unwilling to participate in the study

MRI: Magnetic resonance imaging, LDH: Lumbar disc herniation, PACS: Picture archive and communication system, AIS: Adolescent idiopathic scoliosis

Table 2. Flowchart of the study population



MRI: Magnetic resonance imaging, AIS: Adolescent idiopathic scoliosis, PACS: Picture archive and communication system

Inc., New York, NY, USA). The radiographs were obtained as standing whole spine X-rays in posterior-anterior and lateral standard position. X-rays were taken pre-operatively, immediate post -operatively, at the 1st (first outpatient visit), 3rd and 6th month, annually and at the latest FU appointment.

Clinical Outcome Parameters (ROP)

As patient reported outcome questionnaires Oswestry Disability Index (ODI) scores (section 8 - sex life was omitted), visual analogue scale (VAS) back-leg scores were applied to evaluate the clinical and functional outcomes. Short form 36 (SF-36) score was applied to evaluate health related quality of life.

Surgical Technique

Standard lumbar microdiscectomy procedure was applied to all of the patients from the symptomatic side.

Post-operative Rehabilitation Protocol

Patients were mobilized immediately after surgery and were allowed to return to daily activities after discharge, while return to sportive activities (including non-contact sports, swimming and light gym) were allowed after 1st post-operative month.

Information of Informed Consent

All patients were taken informed consents, so that their pre, intra- and post-operative data including the X-rays could be used for publication by hiding their identity.

Statistical Analysis

For the statistical analysis, SPSS software (Version 22.0; SPSS Inc, Chicago, IL, USA) was used. Data are expressed as mean +/- standard deviation. The chi-square test and Fisher's exact test were used for the analysis of categorical variables and to compare different time points where appropriate. One-Way Analysis of Variance (ANOVA) was used to determine a significant difference at various time points. A p-value less than 0.05 was considered as statistically significant.

RESULTS

Eighteen patients (7 females, 11 males) had an average age of 17.1 (range 14-18) and average duration of FU of 36.8 months (range 24-48). Among them, 10 patients (55.6%) had low back + leg pain, 5 patients (27.8%) had only low back pain, 3 patients (16.6%) had only leg pain. Straight-leg raise (SLR) was positive in 16 patients (88.9%), while contralateral SLR test was positive in 2 patients (11.1%). Level of LDH was L4-L5 in 11 patients (61.1%) and L5-S1 in 7 patients (38.9%), while no patient had two levels of LDH Table 3. 16 patients (88.9%) were detected to have the LDH at the convex side of the lumbosacral curve. Patients were all diagnosed as AIS before presenting to us and were treated for AIS (13 patients were applied thoracolumbosacral orthosis (TLSO), 5 patients were followed up conservatively). All patients underwent one level (L4-L5: 11 patients or L5-S1: 7 patients) microdiscectomy after having been presented to us. Average duration from the onset of SS, until lumbar microdiscectomy was 6.1 months (range 3-10) Table 3.

Radiographic Outcomes

Patients had an average pre-operative Cobb angle of 25.1° (range 18°-29°), which was corrected to 4.2° (range 3.3°-7.2°) at the final FU (p<0.001). Sixteen patients (88.9%) were detected to have the herniated lumbar disc at the convex side of the lumbosacral curve. Fourteen patients (87.5%) were detected to have a trunk shift toward the opposite side of the LDH. It was detected, that all patients had a short lumbosacral curve accompanied with long thoracic curve directed mostly to the opposite side (14 patients, 87.5%) of the LDH. Patients were detected to have average CSVL to C7PL distance of 4.1 cm (range 2.7-6.4) reduced to 1.3 cm (range 0.2-1.4 cm) at the latest FU (p=0.003), indicating the restoration of coronal balance and resolution of SS Table 4. At the 6th post-operative month, 15 (83.3%) of patients were detected to have a complete resolution of scoliosis, while at the latest FU none of the patients was detected to have any residual curve.

Table 3. Data regarding the patients' demographics, clinical exam and operative information

Number of patients (n)	18 (7 females, 11 males)
Average age of patients	17.1 (range 14-18)
Average duration of follow-up (months)	36.8 (range 24-48)
Pain (n) (%)	10 (55.6%): Low back + leg 5 (27.8%): Only low back 3 (16.6%): Only leg
Straight-leg raise test (n) (%)	16 (88.9%)
Contralateral straight-leg raise test (n) (%)	2 (11.1%)
Level of lumbar disc herniation (LDH) (n) (%)	11 (61.1%): L4-L5 7 (38.9%): L5-S1
Average duration from the onset of sciatic scoliosis, until lumbar microdiscectomy (months)	6.1 (range 3-10)
Type of operation for all: One level lumbar microdiscectomy	11 (61.1%): L4-L5 7 (38.9%): L5-S1

Clinical Outcomes

Patients were detected to have a pre-operative average ODI score of 36.1% (range 33.7-46.1), improved to 6.2% (range 3.8-7.2) at the latest FU (p<0.001). Pre-operative VAS leg-back scores of 7.1 (range 6-8)-4.2 (range 3-5) were improved to 1.3 (range 0-2)-0.7 (range 0-1), respectively (p<0.001 for both). Patients' average pre-operative SF-36 physical component score - mental component score of 44.2 (range 43.1-45.3)-46.8 (45.7-48.4) were improved to 56.2 (range 55.3-57.6)-57.3 (range 56.9-57.4) at the latest FU (p=0.003) Table 4. Figure 1.

DISCUSSION

SS was defined as a non-structural scoliosis, which occurred as a natural result of nerve root irritation caused by LDH in most of the cases[1,14]. While the association between SS and LDH well documented, the mechanism and significance was not clearly perceived[7,15]. SS was characterized with a trunk shift, which as hypothesized was tilted laterally to one side as in response to nerve root irritation or hyperactivity of the paraspinal muscle spasm, with the effort to decompress the irritated neural structure and alleviate the pain accompanied to it[4,16,17]. Because of the higher spinal flexibility of the adolescent spine as compared to adult spine, SS was also reported with higher incidence in adolescents varying between 9% to 82%[1,7,18-20]. Zhang et al.[1] reported an incidence of 34.6% for SS in adolescents, while Ozgen et al.[20] reported, that 47% of adolescent LDH patients concomitantly had SS. The present study reported an incidence of 11.7% for SS in adolescents with LDH. Presentation of LDH in adolescents might be radically different than in adults. While neurologic signs including sensory and motor losses was rarely reported in adolescents, SS on the contrary was reported to be a frequent symptom in adolescents, who might also present with SS as the first sign of LDH[21,22]. Due to this fact, a thorough history taking and physical exam is paramount in adolescents presenting with scoliotic posture and vague signs of LDH[2,7,20]. The present study reported, that 55.6% of patients were presented with low back+leg pain, while 27.8% had only low back pain and 16.6% only had leg pain. Adam's forward bending test was shown to distinguish between a structural and non-structural curve. Because of the lack of rotation in non-structural curves, like in sciatic scolisos, Adam's forward bending test would also be negative[1,3]. In fact, the authors of the present study used this test as a criterion of inclusion and only those patients with a negative test were included as mentioned before. On the other hand, lack of a thorough physical exam was reported in long delays of definitive treatment of LDH and in mistreatments as if the diagnosis was AIS, as well[1,2]. Zhu et al.[2] reported, that 4 adolescent patients with LDH accompanied with SS were misdiagnosed as AIS and tried to be managed with bracing. In the present study 13 patients were misdiagnosed as AIS and were applied TLSO.

L4-L5 is the most frequently reported level for LDH in adolescent patients presenting with SS[1,3,7,18]. This information was backed up with the fact, that bilateral iliolumbar ligaments originating from the transverse process of L5 had an important stabilizing role at the level of L5-S1, while L4-L5 level which

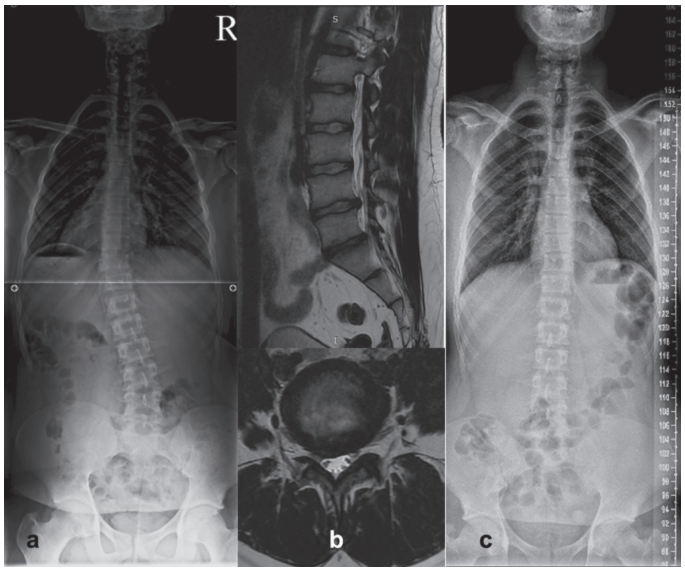


Figure 1. Seventeen year old male patient with lower back and leg pain. **a.** Short lumbosacral curve with long thoracolumbar curve (23.7°). CSVL-C7PL: 3.1 cm **b.** L4-L5 right sided lumbar disc herniation located on the convex side of the curve and creating sciatic scoliosis toward the opposite side **c.** Patient after 38 months as pain free. Sciatic scoliosis completely resolved. Coronal balance restored (CSVL-C7PL: 0.6 cm)

CSVL: Central sacral vertical line, C7PL: C7-plumb line

Table 4. Radiographic, clinical, functional outcomes and scores regarding the health related quality of life

	Pre-operative	At the last follow-up	p-value
Average major curve magnitude	25.1° (range 18°-29°)	4.2° (range 3.3°-7.2°)	<0.001
CSVL-C7PL distance (cm)	4.1 (range 2.7-6.4)	1.3 (range 0.2-1.4 cm)	0.003
Average ODI score	36.1% (range 33.7-46.1)	6.2% (range 3.8-7.2)	<0.001
Average VAS leg score	7.1 (range 6-8)	1.3 (range 0-2)	<0.001
Average VAS back score	4.2 (range 3-5)	0.7 (range 0-1)	<0.001
Average SF-36 PCS	44.2 (range 43.1-45.3)	56.2 (range 55.3-57.6)	0.003
Average SF-36 MCS	46.8 (range 45.7-48.4)	57.3 (range 56.9-57.8)	0.003

CSVL: Central sacral vertical line, C7PL: C7-plumb line, ODI: Oswestry Disability Index, VAS: Visual analogue scale, SF-36: Short form 36, PCS: Physical component score, MCS: Mental component score

was not surrounded by the pelvic cavity might increase its chance to progress to shift and result in SS[23,24]. Kim et al.[18] reported, that having a herniated disc at L4-L5 was a risk factor for developing SS. In conjunction with the literature, 61.1% of the herniated level in adolescent patients with SS was reported as L4-L5 in the present study. Adolescent patients with LDH was reported to be less responsive to conservative treatment, which was attributed to healthy discs with high elasticity and viscosity[6,9,21]. The present study also reported a failure of conservative management in 6 adolescent patients with LDH and SS. Nevertheless, the conservative treatment was suggested to be brief for patients with persisting disability, even in the absence of neurological deficits[2,21]. Surgical treatment was aimed to provide immediate pain relief, quicker recovery and fewer complications[3,7,25]. Good to excellent results were reported as a result of lumbar discectomy in adolescents with LDH[2,3,7]. Zhu et al.[2] suggested, that earlier discectomy could provide greater opportunity for correction and stabilization of SS, without risking the SS to progress into a persistant curve defining a structural scoliosis. Suk et al.[3] suggested to remove not only the herniated disc fragment, but also hypertrophied ligamentum flavum, hypertrophied medial facet together with the decompression of the neural foramen. The present study, in conjunction with the recent literature reported excellent clinical and functional outcomes as a result of meticulously performed lumbar microdiscectomy, performed similarly to Suk et al.[3] suggestions, applied to adolescent patients with LDH and SS. Suk et al.[3] underlined the importance of SLR test as the only factor effecting the clinical outcome by mentioning, that the more limited the SLR test, the better the clinical outcome as a result of surgery. Khuffash and Porter[26] reported, that contralateral SLR test positivity was associated with poor prognosis as managed conservatively. This argument was also confirmed by the study conducted by Suk et al.[3]. In conjunction with the literature, the present study reported, that adolescent patients with highly restricted SLR test [which was the case in all 16 patients (88.9%) included in the present study] had excellent clinical outcomes including ODI and VAS scores in addition to high quality of life evaluated with SF-36 scores at the latest FU visit, while contralateral SLR test was positive on two patients with successful outcomes. According to Finneson's[27] hypothesis, not based on a clinical study, when LDH was lateral to nerve root, the list was towards the opposite side of the sciatica to decompress the nerve root, on the contrary, when LDH was located medial to nerve root, the list was towards the side of the sciatica to decompress the nerve root. However, there are studies contradicting with the hypothesis of Finneson[7,27-29]. It was repeatedly reported, that adolescent LDH patients with SS had short lumbosacral curves, accompanied with long thoracic or thoracolumbar curves directed toward the opposite side, while LDH was noted at the convex side of the lumbosacral curve[1-3,7,18]. Zhu et al.[2] reported 73.1% as the rate of the truncal shift toward the opposite side of disc herniation, by speculating, that this position might decrease the amount of weight bearing on the affected leg providing alleviation of the nerve root irritation. The present study, in conjunction with the literature reported, that all patients had a short lumbosacral curve accompanied with long thoracic curve; while the trunk shift was directed mostly to the opposite side (14 patients, 87.5%) of the LDH, which was on the convex side of the lumbosacral curve in 88.9% of patients. Now that, the SS was secondary to nerve root irritation, it was hypothesized, that it should be resolved, when the painful compression was removed[3,7,25]. The reversibility of the SS together with improvement of symptoms were reported by many studies[1,3,4,19]. However, data regarding the period of curve resolution is conflicting. Matsui et al.[7] reported a complete disappearance of trunk shift in 45% of patients with average 107 days after surgery, while an average curve magnitude of 10.7° was reduced to 2.7° after 7.5 months. Kim et al.[18] reported the reversibility of trunk shift with an average of 6 months. Suk et al.[3] reported, that SS with an average pre-operative magnitude of 9.8° was reversible to 1.8° at the first post-operative week and was less than 5° in 82.2% of cases in the last FU. Zhu et al.[2] reported, that 94.2% of patients recovered to normal in the 2.5th post-operative year. Zhang et al.[1] reported, that 85.71% of adolescent patient obtained scoliosis resolution at the 6th post-operative month. The present study reported, that at the 6th post-operative month, 15 (83.3%) of patients were detected to have a complete resolution of scoliosis, while at the latest FU patients were detected to have an average curve magnitude of 4.2° indicating the almost total resolution of scoliosis. It was also detected, that the slight pre-operative coronal imbalance was successfully restored at the last FU in conjunction with the literature. Highly improved clinical and functional outcomes following discectomy to adolescent patients with LDH and SS have been reported in the literature. Zhang et al.[1] reported average VAS back-VAS leg- and ODI scores of 0.72-0.42 and 7.52 at the final FU. Zhu et al.[2] reported an average ODI score of 7.3% at the final FU. The present study reported average VAS back-VAS leg-ODI scores of 0.7-1.3-6.2%, respectively at the final FU underlining the efficacy of the microdiscectomy. For the first time in the literature, by utilizing SF-26 scores, the present study also reported about the significant improvement of healthy related quality of life regarding this particular group of patients.

Study Limitations

This study has some limitations. First of all it is a retrospective review of patients. Another limitation is, that the number of patients are limited, but this fact was owed to strict inclusion criteria. The strengths of this study are, that contains a homogenous group of patients with regard to their diagnosis, surgical treatment modality and FU duration, and that patients have been enrolled in the study under very strict inclusion criteria to minimalize the potential reasons of bias. Considering the average FU duration of the present study, it is one of the largest in the literature. We believe having presented the

long-term objective results of this very homogenous group of patients to enlighten the controversy with regard to optimal treatment strategy of this rare entity.

CONCLUSION

LDH in adolescents is a rare entity comprising unique clinical characteristics. SS in was mainly associated with short lumbosacral curves accompanied with long thoracic and/or thoracolumbar curves, with minimal or no rotation at all, while the LDH was often located at the convex side of the curve. Lumbar microdiscectomy was able to yield an immediate relieve of the radicular pain in addition to excellent functional outcomes, while successfully restoring the coronal balance in the long term follow-up.

Ethics

Ethics Committee Approval: The study was approved by the Institutional Review Board of EMSEY Hospital (approval date: 02/02/2021, approval no: 1121077).
Informed Consent: Retrospective study.
Peer-review: Externally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: Y.E., T.P., Concept: Y.E., T.P., Design: Y.E., T.P., Data Collection or Processing: Y.E., T.P., Analysis or Interpretation: Y.E., T.P., Literature Search: Y.E., T.P., Writing: Y.E., T.P.
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Conflict of Interest: The authors have no conflicts of interest to declare.

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