Orthodontic management of a patient with short root anomaly and impacted teeth

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Short root anomaly (SRA) is a rare familial dental condition that is often misdiagnosed. Orthodontic treatment of patients with SRA is challenging because it is difficult to diagnose, it may be accompanied by other dental anomalies, and it has been reported to contribute to additional susceptibility to root resorption during orthodontic treatment. In this article, we describe a methodical and evidence-based means of diagnosing and orthodontically managing a patient with SRA. The patient had additional challenges, including impacted and ectopic teeth. An individualized treatment plan that incorporated efficient and effective mechanics led to a well seated occlusion and an esthetic smile. (Am J Orthod Dentofacial Orthop 2019;155:421-31)

Short root anomaly (SRA) is a rare condition in which the roots of the teeth are abnormally short and blunted albeit complete in formation. SRA has been reported intermittently in the literature, with a definitive description of the anomaly in 1972.[1] The pathognomonic features of SRA are as follows: The teeth have short plump roots with rounded apices and crown-to-root ratios of 1:1; the shortness of the root (rizomicry) is not due to root resorption or any factor that is exogenous in origin; there is familial predilection; the apices of the roots are closed; and the teeth are often asymptomatic.[1]

The prevalence of SRA among white populations has been reported as 1.3%[2]-2.4%.[3] Generalized forms of rizomicry have been reported,[4] and a higher prevalence for localization of the condition in the maxillary incisors and premolars has been observed.[5] Baccetti et al found a correlation between distal inclination of the mandibular second premolar bud and palatally displaced canines, small maxillary lateral incisors, and dental aplasia.[6] These anomalies in turn have been associated with SRA,[7] suggesting the presence of an altered gene-regulatory mechanism. Therefore, the percentages cited above may be underrepresentative, especially because SRA may be part of a continuous spectrum of dental anomalies.

Differential diagnosis for teeth with short roots can be challenging, especially in a young patient. For more generalized forms of SRA, the existence of definitive etiologic factors, such as systemic factors,[8] syndromes[9-11] and genetic disorders,[12] must be investigated. However, generalized forms of SRA with an associated familial history can occur in isolation of other conditions.[4,13] Differential diagnosis for localized forms of SRA can include incomplete or delayed root formation and/or root hypoplasia occurring after dental trauma, and they must be ruled out with the use of a thorough dental and family history.[14] However, the most common misdiagnosis for both localized and generalized SRA is idiopathic root resorption (IRR),[7] because both are asymptomatic with a predilection for females.[2,15]

Some helpful diagnostic clues to differentiate SRA and IRR are: (1) SRA is usually bilaterally symmetric[1,2] with smooth apical blunting as opposed to irregularities in the root accompanying resorption[16]; and (2) association with other developmental anomalies and familial history also provide helpful diagnostic clues for SRA.[7] The distinction between the two is important from a clinical standpoint because IRR, unlike SRA, may have varying periods of progressive resorption.[15,16] Although certain reports have noted an increased propensity for root resorption in patients with SRA,[1,7] it has not been

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Fig 1. Pretreatment facial and intraoral photographs.

corroborated through research. It can be hypothesized that the increased susceptibility is probably due to known risk factors for root resorption in patients undergoing orthodontic treatment,[17] such as a decrease in the ratio of root to crown,[18] as well as an anomalous dental morphology[19] and not due to the inherent nature of the anomaly.

This report presents the orthodontic management and treatment of a patient with SRA associated with multiple impacted teeth, ectopically erupted teeth, and peg-shaped laterals. It also discusses the diagnostic and clinical considerations for orthodontic treatment of SRA patients.

DIAGNOSIS AND ETIOLOGY

A 14-year-old postpubertal girl presented to our orthodontic clinic with the chief complaint of gaps between her upper front teeth. The patient's medical history was noncontributory and she had received regular dental care. She had a symmetric mesoprosopic face with a convex soft tissue profile, obtuse nasolabial angle, and retrusive lips. Intraorally, she had a Class I molar relationship bilaterally, with her left molars in crossbite. The upper right canine was ectopically erupted and she had microdontia of her upper lateral incisors. The dentition was spaced in both arches (Fig 1). Panoramic radiographs revealed distally tipped and unerupted mandibular second premolars with delayed apical closure, impacted upper left canine, and shortened roots on all upper premolars, lower second premolars, and the distal roots of the upper first molars (Fig 2). Cephalometric analysis indicated a skeletal Class I relationship with a normovergent mandibular plane angle. The upper and lower incisors were slightly retroclined. The upper and lower lips were retrusive to the E-line (Fig 3; Table I).

An accurate diagnosis was imperative to provide optimal treatment and address the patient's chief complaint. To buccolingually locate the impacted teeth and simultaneously analyze the crown-to-root

Fig 2. Pretreatment panoramic radiograph.

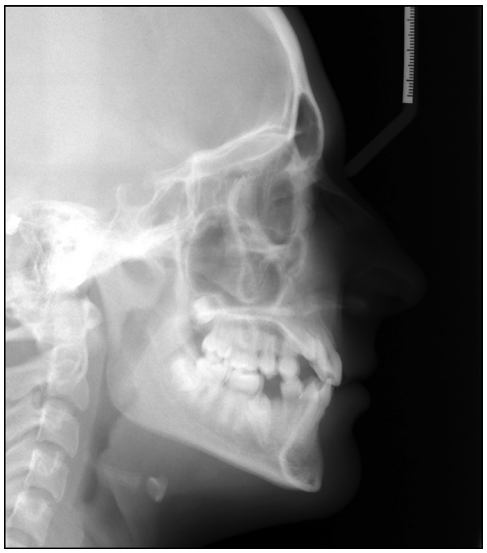

Fig 3. Pretreatment lateral cephalometric radiograph.

Table I. Cephalometric analysis

Measurement	*Normal*	*Before treatment*	*After treatment*
SNA (°)	82.0 ± 2.0	79	79
SNB (°)	80.0 ± 2.0	76.5	76.5
ANB (°)	2.0 ± 2.0	2.5	2.5
SN-MP (°)	32.0 ± 5.0	36	36
FMA (°)	24.0 ± 4.5	25	26
U1-SN (°)	102.0 ± 5.5	97	90
U1-NA (mm)	4.3 ± 2.7	3	1
L1-MP (°)	95.0 ± 7	95	94
L1-NB (mm)	4.0 ± 1.8	4	3.5
Interincisal angle (°)	130.0 ± 6.0	135	138
Upper lip to E-line (mm)	−4.0 ± 2.0	−8	−10
Lower lip to E-line (mm)	−2.0 ± 2.0	−7	−7

ratios, intraoral periapical (IOPA) radiographs were taken and the Clark rule or the buccal object rule was applied (Fig 4). Before exposure of the impacted teeth, the periodontist requested a cone-beam computed tomographic (CBCT) scan, which is

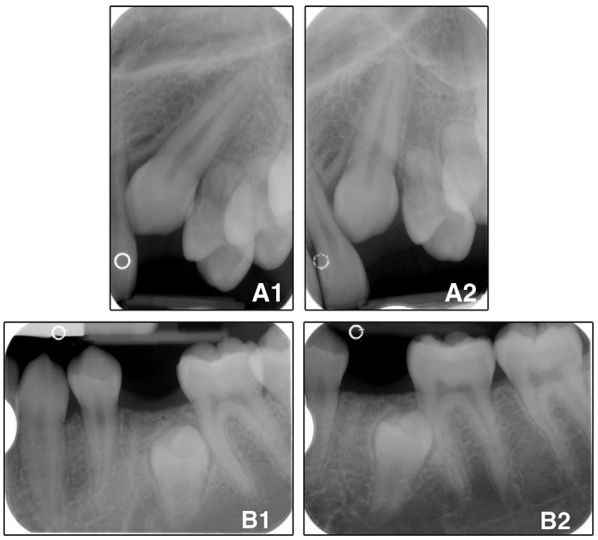

Fig 4. Periapical radiographs with Clark rule: **A,** upper left canine; **B,** lower left second premolar.

considered the standard of care in unusual impactions such as the lower left second premolar. Because both impacted teeth were on the left side, a CBCT scan with a limited field of view captured both teeth (Fig 5). We also examined previously available panoramic radiographs of the patient's parents and sibling (Fig 6). Shortened premolar roots and an impacted tooth were diagnosed in her sibling's radiograph. The diagnosis of SRA was made for the patient based on the presence of familial inheritance, bilateral symmetry, root morphology, and associated developmental anomalies.

TREATMENT OBJECTIVES

In accordance with the pretreatment records and the patient's chief complaint, the treatment objectives were to (1) prevent any further root shortening in teeth with SRA (due to unusual root morphology), (2) carefully expose and orthodontically extrude the impacted teeth and bring the ectopically erupted teeth into alignment, thereby closing the spaces in both the maxillary and mandibular arches, (3) correct the crossbite in the left molar region, (4) maintain Class I molar relationship bilaterally, and (5) achieve ideal overjet and overbite as well as coincident dental and facial midlines with good smile esthetics.

TREATMENT ALTERNATIVES

Keeping in view our treatment objectives and to attain the best esthetic and functional results, 2 treatment options were proposed to the patient. Both were

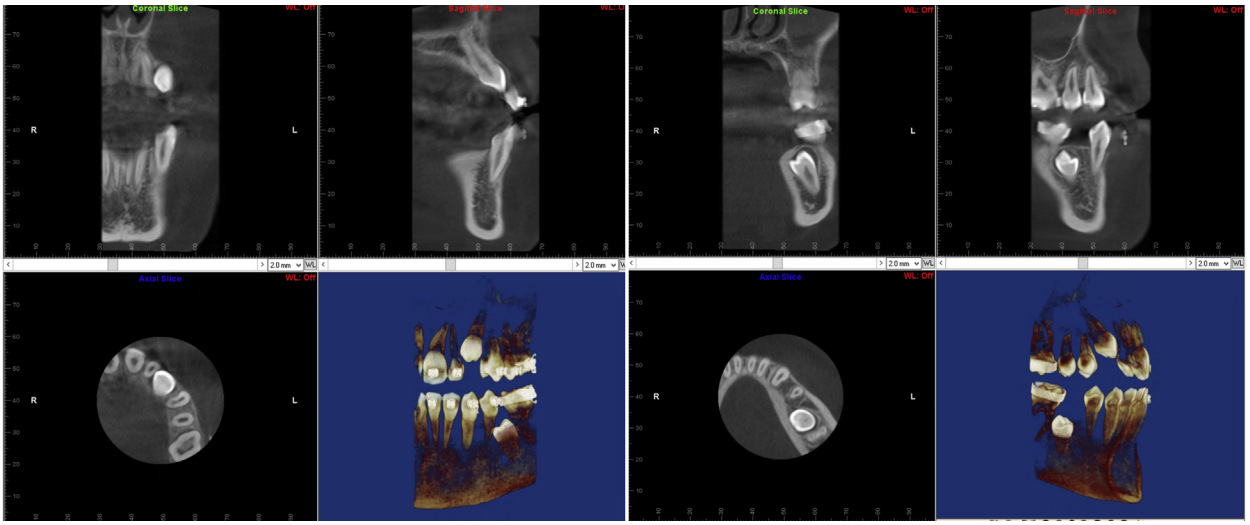

Fig 5. CBCT images of impacted upper left canine and lower left second premolar.

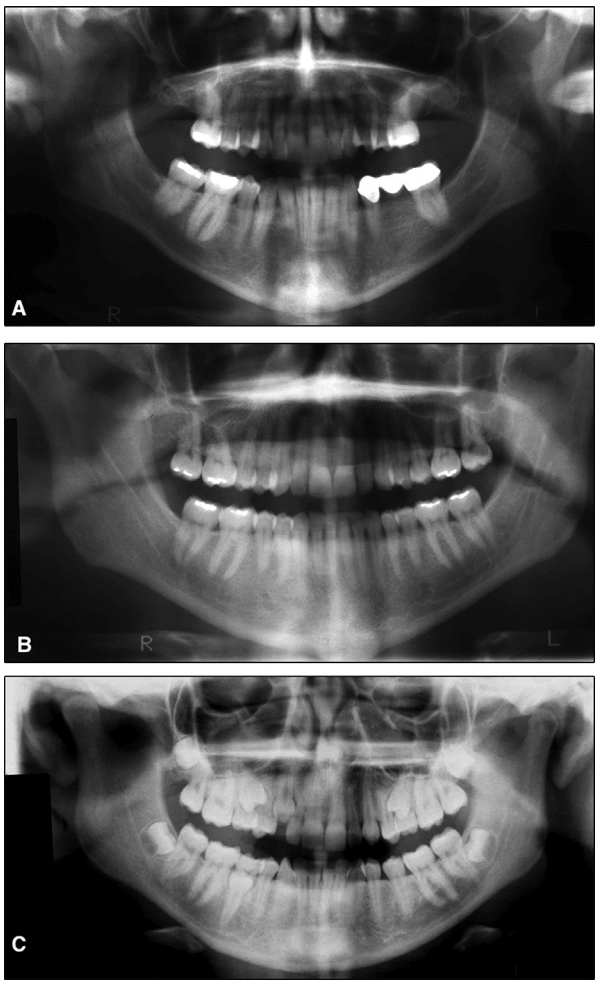

Fig 6. Panoramic radiographs of patient's family: **A,** father; **B,** mother; **C,** older sister.

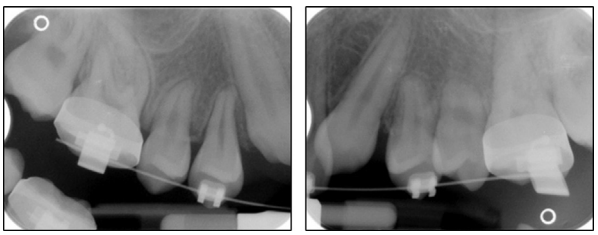

Fig 7. Periapical radiographs after 3 months of treatment.

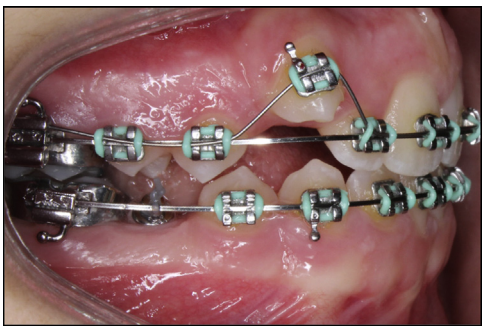

Fig 8. Progress intraoral photograph: extrusion of upper right canine and lower right second premolar.

nonextraction options, taking into consideration the patient's profile, lip support, and space analysis.

The first option was to use the concept of therapeutic diagnosis and proceed with regular mechanics without anchorage reinforcement for the orthodontic traction of the impacted teeth. To determine the susceptibility of teeth with SRA to resorption, it was proposed to initially bond only 1 of the upper premolars bilaterally (first premolar) and apply orthodontic force.

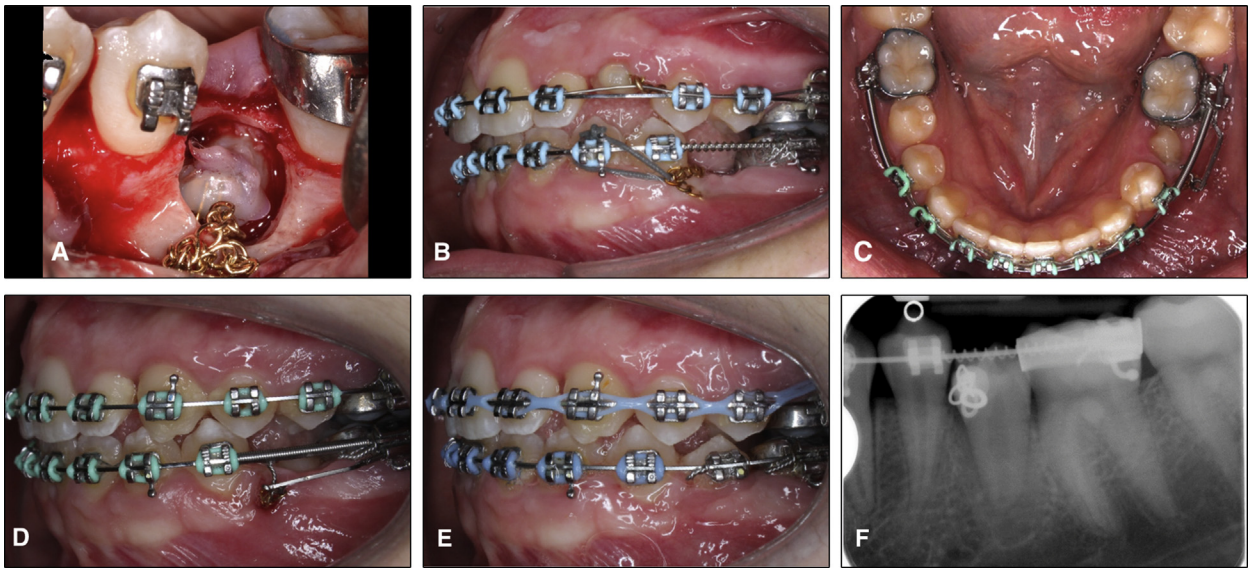

Fig 9. Progress intraoral photographs: orthodontic traction of the lower left second premolar and follow-up radiograph.

Furthermore, follow-up periapical radiographs of the upper premolars were built into the plan. Based on the response of the teeth with SRA that were bonded, the exposure and orthodontic traction of the impacted teeth and bonding of the control teeth with SRA would be planned.

The second option involved the use of temporary anchorage device–supported traction of the impacted teeth with delayed bonding of other teeth along with minimal orthodontics for aligning and finishing. This option was considered because earlier reports have found that underestimation of anchorage demands is one of the major reasons for failure in the treatment of impacted canines.[20] Therefore, this option was also presented as an alternate plan to the first option if the teeth with SRA did not respond well to orthodontic forces. Risks and benefits for each treatment option were discussed at length with the patient and her parents, and the first treatment option was adopted with their consent.

TREATMENT PROGRESS

Preadjusted edgewise brackets (0.022 × 0.028 inch) were bonded on all erupted teeth except the upper second premolars, which served as control teeth. The upper right canine was bypassed during initial leveling. Both arches were leveled and aligned with the use of 0.016-inch nickel-titanium (NiTi) continuous archwires. Periodic radiographic evaluations of the upper premolar region were obtained every 3 months (Fig 7). Visual inspection indicated no drastic change in the root length and morphology of the maxillary first premolars. Six months into the treatment, the upper second premolars were bonded and both arches were built up to 0.019 × 0.025-inch stainless steel archwires sequentially. Orthodontic traction was applied by means of piggyback mechanics with the use of NiTi wires to the upper right canine and lower right second premolar, which was surgically exposed in the orthodontic clinic itself owing to its superficial positioning (Fig 8). At this time, a decision was made to expose and orthodontically extrude the impacted teeth, namely, the upper left canine and lower left second premolar. Based on progression of the root development of the lower left second premolar toward apical closure and the diagnosis of SRA for the contralateral second premolar, it seemed unlikely that the lower left second premolar would develop a longer root. Moreover, studies have demonstrated that orthodontic movement of immature teeth does not lead to adverse effects in root formation and in fact may be advantageous.[21] The patient was referred to the department of periodontics for the exposure of the upper left canine and lower left second premolar (Fig 9, *A*). The CBCT image revealed a fairly uncomplicated midalveolar positioning of the upper left canine with mild resorption of the cervical third of the adjacent upper left lateral incisor. In contrast, the lower left second premolar was distolingually tipped and approximating the mesial root of the first molar and

Fig 10. Posttreatment facial and intraoral photographs.

placed 4-5 mm deep within the alveolar bone (Fig 5). After exposure, the initial force on the lower left second premolar was applied with the use of an elastic chain to mesialize the tooth away from the molar root (Fig 9, *B*). Once it had moved away from the molar root, a cantilever was used to bring the premolar into the arch (Fig 9, *C* and *D*). A follow-up radiograph was taken to assess the root development and tooth position (Fig 9, *F*).

Eighteen months into treatment, all teeth were leveled and aligned and space closure was completed. A panoramic radiograph was taken to assess the positions of the roots as well as evaluate for root resorption. Bracket repositioning followed by finishing and detailing was completed. To obtain ideal overjet despite the tooth-size discrepancy, the patient was given options of building up the upper laterals versus interproximal reduction in the lower anterior region. The patient chose the latter option. The total treatment time was 24 months. A Hawley retainer was delivered in the upper arch, and a lingual fixed retainer was bonded on the lower anterior teeth for retention.

TREATMENT RESULTS

The patient was very satisfied with the result because her chief complaint had been addressed and she had an esthetically pleasing smile, as seen in the posttreatment photographs (Fig 10). The discrepancy that would exist in the gingival zeniths of the upper anterior teeth due to microdontia of the upper laterals had been explained to the patient previously. She found it esthetically acceptable and did not want build-ups or veneers. A well seated Class I molar and canine relationship had been achieved (Fig 10). The posttreatment clinical evaluation revealed no mobility of the teeth with SRA. The panoramic radiograph showed good root parallelism and root development as well as apical closure of the lower left second premolar (Fig 11). The posttreatment lateral cephalometric

Fig 11. Posttreatment panoramic radiograph.

Fig 12. Posttreatment lateral cephalometric radiograph.

analysis and superimposition revealed minimal growth and maintenance of the soft tissue profile (Figs 12 and 13). One year after retention, facial and intraoral photographs showed a stable occlusion (Fig 14). One-year postretention IOPA radiographs were obtained for the upper first and second premolars bilaterally because they were severely affected with SRA and were subjected to the maximum orthodontic stress (Fig 15). Root resorption was measured for each of the premolars by comparing them with the initial 3-month periapical radiograph (Fig 7) by means of the technique proposed by Linge and Linge[22]; the results are presented in Table II. Of the 4 premolars, the upper right second premolar showed the maximum resorption, 0.5 mm, which is within the range of clinically acceptable orthodontically induced external root resorption.[17]

DISCUSSION

Molecular analysis of the gingival crevicular fluid from SRA patients has revealed that a characteristic feature is the activation, complex formation, and fragmentation of matrix metalloproteinase 9 (MMP-9). MMP-9 has low collagenolytic resorptive activity, thus reinforcing the hypothesis of developmental root shortening in SRA, which is not due to root resorption.[5] Animal studies have also revealed that the loss of nuclear factor I genes results in root shortening due to disrupted odontoblast differentiation,[23] which could lead to future investigative research on the possible biologic basis of SRA in humans. Although unable to clearly delineate the exact inheritance pattern for SRA, studies have established a hereditary and genetic predisposition.[4,7] Furthermore, SRA has been associated with other dental anomalies, such as tooth agenesis, ectopic canines, and peg-shaped laterals leading to further evidence for the existence of a shared genetic mechanism.[2,7]

Previous case reports outlining the management of patients with SRA have used different treatment strategies to minimize the potential complications due to orthodontic forces. Marques et al managed a patient with SRA by specifically addressing the skeletal discrepancy and minimizing orthodontic tooth movement to meet the requirements of the case.[24] In our patient, on the other hand, SRA was associated with dental anomalies such as ectopic and impacted teeth, thus necessitating the use of orthodontic forces.

Treatment of multiple impacted teeth is challenging and time consuming even under normal circumstances.[20] SRA of the impacted teeth and teeth adjacent to the ectopic/impacted teeth led to an added complexity in the present patient. The initial step for such cases should be to determine the correct diagnosis through a thorough patient history and available evidence. In our case, once the diagnosis of SRA was confirmed and the risks communicated to the patient and the parents, an individualized treatment approach was constructed and delivered.

The decision to monitor the root resorption of the teeth with SRA before bonding all teeth was made based on previously published orthodontic literature.[1,2,14] Although orthodontic treatment is not contraindicated, the root form and orthodontic stress patterns postulate an increase in root resorption potential in teeth with SRA.[18,19] Therefore, we followed the recommendations suggested by Valladares et al and used light forces throughout the treatment, allowed longer intervals between activations, and performed periodic monitoring

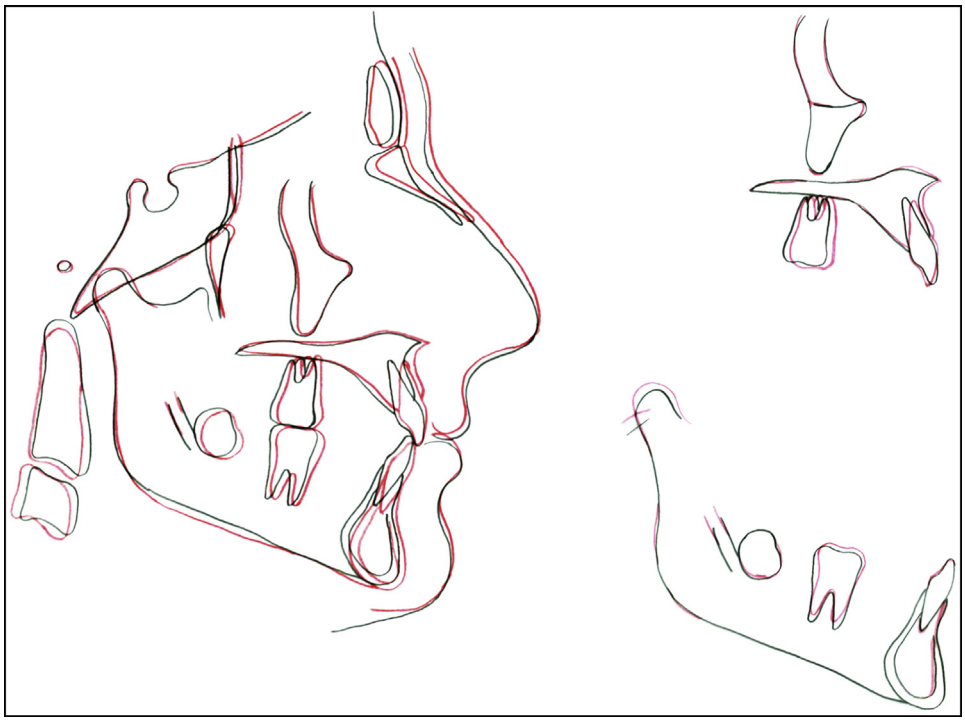

Fig 13. Superimpositions of pretreatment (*black*) and posttreatment (*red*) cephalometrc tracings.

with radiographs.[14] The other decision that was made after considerable deliberation and discussion with the periodontist was the exposure of the impacted lower left second premolar which most likely had SRA but the apical third of the root was still forming. Longitudinal follow-up of tooth movement with partially formed roots has shown favorable results,[25] but there is a scarcity of literature on exposure and orthodontic traction of teeth with incomplete root formation. Some published reports recommend waiting for spontaneous eruption owing to a great amount of variability in the formation and eruption of second premolars in general.[26,27] We decided to carefully expose the lower left second premolar and place gentle orthodontic forces on it to simulate natural tooth eruption based on the scientific evidence that hypothesizes the existence of commonalities in the genetic expression and the end results of the 2 processes.[28] The stepwise mechanics for orthodontic traction was planned with the use of the CBCT images. After an initial mesial force to move the crown of the tooth away from the molar root, a cantilever was designed in such a way that it applied a mesial, buccal, and extrusive force on the premolar. The use of a cantilever from the first molar can easily generate a single light force for eruption of the impacted lower left second premolar because the line of action, the magnitude, and the point of force application can be titrated by the clinician. In our case, a cantilever was made from 0.017 × 0.025-inch Connecticut New Archwire generating a force of 20 cN. From a buccal view, the applied force (F_I) can be resolved into vertical (F_V) and horizontal (F_H) components, which mesialized and extruded the premolar (Fig 16). From an occlusal view, the traction force can be divided into mesiodistal (F_M) and buccolingual (F_B) components, which provided mesial and buccal traction to the premolar. Because this system is in equilibrium, there are distal, intrusive, and constrictive forces on the first molar. The equilibrium forces that were generated on the first molar were dissipated among all other mandibular teeth attached to the rigid main archwire. Small reactivations of the cantilever as the tooth erupted led to its gradual eruption into the oral cavity over a period of 7 months. The root formation also proceeded to completion during this period, attaining the same crown-to-root ratio as the contralateral premolar.

Future studies may conclusively substantiate the presence or absence of resorptive susceptibility for teeth with SRA. Genetic studies are also needed to be able to accurately diagnose the anomaly in the future. However, as the present case demonstrates, as well as based on the evidence in previously published literature, it is possible to narrow down the diagnosis of patients with SRA. We

Fig 14. Six-month follow-up facial and intraoral photographs.

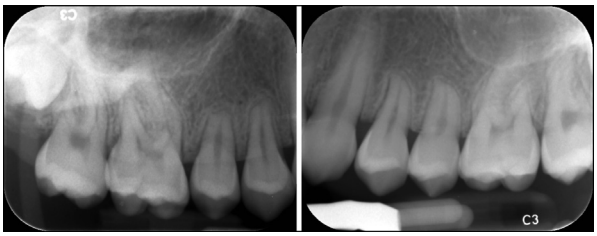

Fig 15. One-year postretention periapical radiographs of the upper premolar region.

used conventional mechanics to treat the patient, although precautionary alternate plans, prudent mechanics, and continuous monitoring with the use of periodic radiographs were incorporated into the treatment plan. We also recommend simplification of the force system, such as the use of the cantilever system as an ideal approach for orthodontic traction, as demonstrated by this case.

Table II. Measurement of crown and root lengths from periapical films

Tooth	*C1*	*C2*	*R1*	*R2*	*OIRR*
#4	7.1 mm	7.0 mm	6.1 mm	5.5 mm	0.5
#5	6.1 mm	7.1 mm	6.0 mm	6.5 mm	0.4
#12	6.4 mm	7.5 mm	6.1 mm	6.7 mm	0.4
#13	6.7 mm	7.4 mm	5.8 mm	6.3 mm	0.1

C1, Initial crown length (3-month radiograph); *C2*, final crown length (1-year follow-up radiograph); *R1*, initial root length (3-month radiograph); *R2*, final root length (1-year follow-up radiograph); *OIRR*, orthodontically induced external root resorption: R1 − R2(C1/C2).

CONCLUSION

The execution of a well defined plan resulted in successful and efficient treatment of impacted teeth in a patient with SRA. Favorable esthetic and functional results were also obtained. Judicious weighing of risks and benefits before commencing treatment is recommended because

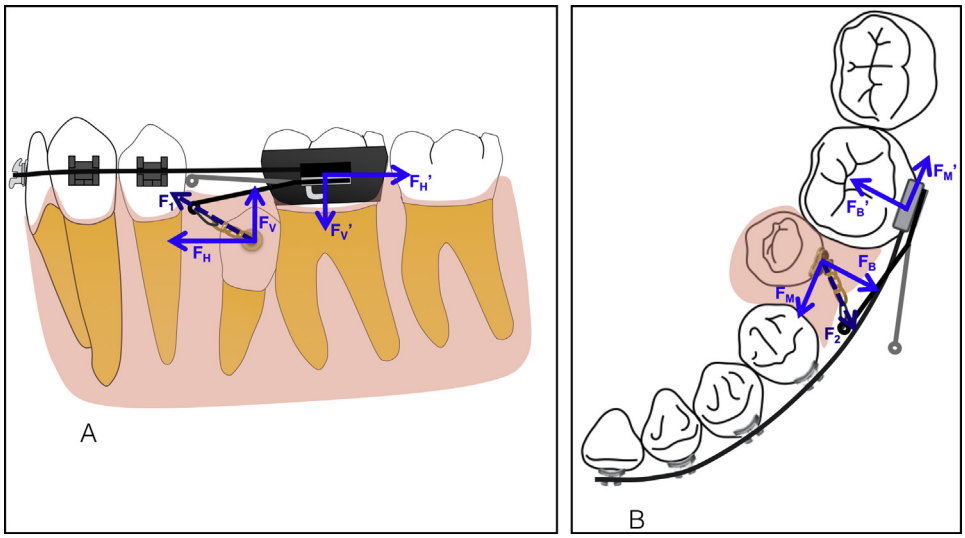

Fig 16. Cantilever biomechanics. **A,** From a buccal view the applied force (F_1) can be resolved into vertical (F_V) and horizontal (F_H) components, which mesialized and extruded the premolar. **B,** From an occlusal view the traction force can be divided into mesiodistal (F_M) and buccolingual (F_B) components, which provided mesial and buccal traction to the premolar. Because this system is in equilibrium, there are distal, intrusive, and constricted forces on the first molar.

each case of SRA will pose unique challenges to the clinician. Finally, we emphasize the need for correct diagnosis to achieve a successful outcome with minimal adverse effects.

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