Int. J. Morphol.,
40(5):1321-1327, 2022.

Root Resorption Pattern in Panoramic Radiographs of Pediatric Patients with Unilateral Posterior Crossbite: A Cross-Sectional and Retrospective Study

Patrón de Reabsorción Radicular en Radiografías Panorámicas de Pacientes Pediátricos con Mordida Cruzada Posterior Unilateral: Estudio Transversal y Retrospectivo

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GONZÁLEZ-CABRERA, C.; TICONA-FLORES, J. M. & DIÉGUEZ-PÉREZ, M. Root resorption pattern in panoramic radiographs of pediatric patients with unilateral posterior crossbite: A cross-sectional and retrospective study. *Int. J. Morphol., 40(5)*:1321-1327, 2022.

SUMMARY: temporary mandibular molars in panoramic radiographs of pediatric patients with unilateral posterior crossbite (UPCB). This cross-sectional and retrospective study analyzed 114 orthopantomograms of patients between 6 - 9 years of age with unilateral posterior crossbite diagnosis. The first and second mandibular molars were analyzed. Their root resorption stage was typified, and the root lengths were measured; to later compare the data obtained depending on the malocclusion side. 86.4 % of molars showed a linear resorption pattern, and atypical resorption prevalence in patients with UPCB was 13.5 %. The total length average of the first molars on the side of the malocclusion was 8.20 mm, while the contralateral exhibited a mean of 9.29 mm. Lastly, the second molars had a mean length of 11.12 mm in crossbite side and 12.30 mm in the normal occlusion side. UPCB could affect physiological resorption by observing a resorption alteration in those mandibular molars located on the malocclusion side.

KEY WORDS: Unilateral posterior crossbite; Root resorption; Malocclusion; Deciduous tooth.

INTRODUCTION

The physiological root resorption mechanism and subsequent exfoliation of primary teeth are a puzzle nowadays. This resorption appears to be initiated and regulated by the stellate reticulum and dental follicle of the underlying permanent tooth through the secretion of stimulating molecules such as cytokines and transcription factors, although temporary teeth lacking a permanent successor also end up exfoliating (Bille *et al*., 2007).

Osteoclast differentiation and functions are regulated by osteoblast-derived factors (Sasaki, 2003). Recent studies mention cellular and ultrastructural changes, which are different in each resorption phase. In the initial resorption stages individual and isolated resorption craters have been observed, which were on the apical surface, however, these are more frequent in the furcation region. In advanced resorption stages, these craters deepen with gaps that host odontoclasts and giant multinucleated cells (Yoon-Hee *et al*., 2000).

During physiological resorption, high enzymatic activity is exhibited (Scarola & Galmozzi, 2001). Primary teeth that have some degree of root resorption are an important source of stem cells resulting from pulp activity, for this reason, these could contribute some function to the physiological resorption process (Bernardi *et al*., 2011; Zhu *et al*., 2013). The cellular metabolic activity during the first resorption stages increases at the same time as the resorption progresses, demonstrating the pulp's importance in the resorption process (Eronat *et al*., 2002). Changes such as an increase in the pulp vascularization flow are evidenced in primary molars' physiological root resorption (Karayilmaz & Kirzioglu, 2011). In addition, a lower neuronal density is observed because of axonal degeneration with the fragmentation of neurofilaments and myelin sheath degradation, which involves greater Schwann cells autophagic death (Suzuki *et al*., 2015). The increase in immune and inflammatory cells may be present in teeth with

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Received: 2022-07-14 Accepted: 2022-08-08

advanced root resorption and this may reflect the recovery capacity of the tooth even in the advanced stages of resorption (Monteiro *et al*., 2009).

Tooth repair can be linked to tooth resorption, in fact, mononuclear cells and the thin organic layer found during the last resorption phase on the previously resorbed adamantine surface plays a relevant role in its repair (Sahara & Ozawa, 2004).

According to some primary dentition periodontal research, fewer groups of Malassez epithelial cells remain and fragments of Hertwig's epithelial sheath are observed to be involved in root resorption protection. Besides, a lower expression of osteoprotegerin has been detected, which is the main protein in the regulation of bone metabolism and osteoclastic activity. These characteristics may be associated with less protection against root resorption in primary teeth (Cordeiro *et al*., 2011).

On the other hand, primary cementoblasts that are subjected to chewing forces and stimulation from proinflammatory cytokines prevent the expression of non-collagen proteins such as bone sialoprotein and proteins derived from cement, both of which are associated with cementogenesis (Diercke *et al*., 2012). The receptor activator of the ligand NF-kappaB probably participates in odontoclastogenesis and also activates physiological root resorption (Fukushima *et al*., 2003). The periodontal ligament stem cells show the proliferative, osteogenic and inducing capacity of osteoclasts, but this proliferative function is reduced during the physiological root resorption of the primary dentition; however, the osteogenic and inducing situation increases (Li *et al*., 2014).

The root resorption of the primary dentition has been studied through radiographic examinations, including orthopantomography. This auxiliary examination has been the most used in pediatric patients because it allows evaluation of the development of the teeth, jaws, and soft tissue, as well as their relationship (Peretz *et al*., 2013; Murthy *et al*., 2020a). Although this method can only provide a two-dimensional representation of a three-dimensional process, such as resorption, it allows an acceptable evaluation of the jaw and the linear process of molar root resorption (Mulia *et al*., 2018).

Knowing and intercepting the risk factors related to the root resorption process in the primary dentition is important because it would help to establish an early diagnosis and treatment, reducing unpleasant effects. Furthermore, this study shows how the abnormal chewing pressure of the unilateral posterior crossbite could affect the development and exfoliation process of primary teeth.

The aim was to describe and compare the pattern of physiological resorption and root lengths of temporary mandibular molars in pediatric patients with UPCB.

MATERIAL AND METHOD

Ethical aspects. This study was evaluated and accepted by the San Carlos Clinical Hospital's Ethics and Clinical Research Committee, Madrid- Spain in 2020 (Internal Code 20/429-E). The Helsinki statements for suitability requirements and ethical precepts for medical research in human beings and their subsequent review were followed, as well as the Spanish applicable laws depending on the characteristics of the research.

Design and environment. A retrospective, observational and cross-sectional study was conducted at the Integrated Children's Clinic of Dentistry School at the Complutense University of Madrid. Also, STROBE guidelines (https://www.strobe-statement.org) were followed.

The Dental clinic's health program was accessed where clinical data and radiographic records were collected from potentially eligible participants. Data extraction was made from June to September 2020.

Eligibility and selection criteria

Inclusion criteria: Children from 6 to 9 years old in mixed dentition with a complete medical history and quality radiographic records. In addition to patients with unilateral posterior crossbite diagnosis (abnormal buccal-lingual relation between opposing posterior teeth in maximum intercuspation) and lower dental midline deviated to the malocclusion side, and healthy deciduous molars or without treatments that do not interfere with the root resorption process were included. Finally, patients whose parents or legal guardians agreed to participate in the study by signing the informed consent were also included.

Exclusion criteria: Patients who presented with radiographic signs of pathological resorption of the roots and/or the surrounding bone, with stainless steel crown treatment or pulp therapy were excluded. Also, children with orthodontic or orthopedic treatment history, incomplete clinical records and those who have had systemic diseases and/or medical treatments that might influence the oral state, and patients with dental alterations in development or number were also excluded. Lastly, the lack of any lower primary molar due to exfoliation was excluded.

Sample size. The sample size was determined considering a 95 % confidence level, an 80 % statistical power, and the 15.3 % prevalence of atypical resorption in clinically healthy deciduous teeth, found by Vieira-Andrade *et al*. (2012). The result was to consider at least 99.43 patients. A total of 320 patients were verified of which 114 met the selection criteria. Therefore, digital panoramic radiographs of 57 boys and 57 girls were analyzed.

Data collection procedures. The principal researcher was previously calibrated and trained, besides being responsible for the selection and participant identification.

Firstly, the patients were selected according to age, followed by a review of medical and dental data from their clinical history. Sex, age, crossbite side, and deviation midline were recorded on a collection sheet.

Secondly, the resorption pattern and root length were identified by analyzing the radiographs. This was conducted on QCAD/CAM 3.24.3 software. Each radiograph was calibrated according to the program scale, all evaluation conditions were standardized and required a maximum of 8 min for each.

The root resorption stage of deciduous molars was characterized, taking as a reference the seven stages proposed by Fanning (2008). The atypical resorption diagnostic criterion was based on a visible discrepancy of mesial or distal root resorption during two or more stages.

To determine the length of each molar, the following reference points were marked: a) maximum coronal mesial convexity, b) the most prominent point of the crown in its distal portion, c) mesial and distal cementoenamel junction, and d) the most apical point of the mesial and distal root (Nanekrungsan *et al*., 2012).

Statistical analysis. IBM® SPSS statistical Software version 26.0 was used. Descriptive analysis was performed by observing measures of central tendency. Paired samples T-student test was used to compare the lengths obtained from the lower molars on the non-crossed and crossed bite sides. And for the contrast of the ordinal variable (absorption stages), a Wilcoxon test was used. The effect size was calculated using Cohen's D test. Finally, a significance of $p < 0.05$ and a power of 80 % were established.

The intra-examiner agreement was done for 30 % of the randomly chosen sample and this second measurement was performed one month after the first measurement. The Kappa coefficient showed substantial agreement (K = 0.774) between both measurements. The index was significant at $p < 0.05$.

RESULTS

Children's X-rays between 6 and 9 years old were evaluated, the sample distribution can be seen in Table I.

Table I. Sex and age distribution.

			Age				Total
			6	7	8	9	
Sex	Female	n	18	14	15	10	57
		%	15.8 %	12.3 %	13.2 %	8.8 %	50.0 %
	Male	n	18	13	15	11	57
		%	15.8 %	11.4 %	13.2 %	9.6 %	50.0 %
Total		n	36	27	30	21	114
		%	31.6 %	23.7 %	26.3 %	18.4 %	100.0 %

Table II. Distribution of root resorption stages.

	Crossbite side				Non-crossbite side			
	1st Molar		2nd Molar		1st Molar		2nd Molar	
Resorption stages	n	%	n	%	n	%	n	%
R 1/4	2	1.8	19	16.7	2	1.8	15	13.2
R 1/3	20	17.5	33	28.9	17	14.9	41	36.0
R 1/2	39	34.2	35	30.7	39	34.2	30	26.3
R 2/3	23	20.2	14	12.3	29	25.4	12	10.5
R 3/4	10	8.8	1	.9	4	3.5	3	2.6
R c	2	1.8	--	--	8	7.0	--	--
Atypical	18	15.8	12	10.5	15	13.2	13	11.4
Atypical resorption distribution								
RM 1/4 RD 1/2	--	--	1	.9	--	--	--	--
RM 1/3 RD 2/3	1	.9	--	--	2	1.8	--	--
RM 2/3 RD c	2	1.8	--	--	--	--	1	.9
RM 1/2 RD 1/4	--	--	2	1.8	--	--	2	1.8
RM 2/3 RD 1/3	--	--	4	3.5	2	1.8	5	4.4
RM 2/3 RD 1/2	1	.9	--	--	--	--	1	.9
RM 2/3 RD _	--	--	1	.9	--	--	--	--
RM 3/4 RD 1/2	3	2.6	4	3.5	4	3.5	4	3.5
RM c RD 2/3	5	4.4	--	--	4	3.5	--	--
RM c RD 1/2	3	2.6	--	--	2	1.8	--	--
RM c RD 3/4	3	2.6	--	--	1	.9	--	--
Total		114				100.0 %		

Eighty-two to eighty-nine percent of molar teeth root resorption ware categorized as stages proposed by Fanning (2008). The frequency of atypical resorption on the crossbite side was 13.15 % and 28 cases were observed on the non-crossed side of the 114 molars examined; the distribution of the resorption stages is detailed in Table II.

The 64.9 % of the first molars and 71.92 % of the second molars on the crossbite side had similar resorption stages to their contralateral, showing a $p > 0.05$. (Table III).

Table III. Resorption stages comparison of the first and second molars between crossbite (CB) and non-crossbite sides (NCB).

	Positive ranks [a]	Negative ranks [b]	Zero [c]	Z [d]	P - value
First molar	9	5	74	-.881	.378
Second molar	6	6	82	-.489	.625

a. Resorption stage NCB > resorption stage CB. b. Resorption stage NCB < resorption stage CB. c. Resorption stage NCB = resorption stage CB. d. Wilcoxon signed-rank test

The mean measurement of the first molar on the non-crossbite side is 1.02 mm greater than on the crossbite side (Table IV). When comparing the means distributed by age in the box plot (Fig. 1), a decrease in mean length is observed as age increases.

The mean measurement of the second molar on the non-crossbite side is 1.18 mm greater than on the crossbite side (Table IV). When comparing the mean measure by age in the box plots (Fig. 2), a decrease in mean length is observed as age increases. similar to the first molar.

All measurements of the non-crossbite side were greater than the crossed side with a $p < 0.05$. A 0.94 Cohen's D value for the first molar means that 82.6 % of the total measure of the first molars on the crossbite side are below the mean of its contralateral. For the second molars, a -1.21 Cohen's D value indicates that 88.7 % of the second molars on the crossbite side are shorter than the average length of the non-crossbite side (Table V).

Table IV. Molar measurements.

		First molar measurements.				Second molar measurements.			
		Mean	Median	SD	Variation	Mean	Median	SD	Variation
Crossbite side	Coronal length	3.68	3.64	0.46	0.21	4.84	4.84	0.40	0.16
	Mesial root	4.21	4.58	2.03	4.13	6.30	6.14	1.20	1.46
	Distal root	4.59	4.71	1.41	1.99	6.54	6.51	1.12	1.27
	total measure	8.20	8.17	1.48	2.19	11.13	11.14	1.30	1.70
Non-crossbite side	Coronal length	4.06	4.01	0.48	0.23	5.27	5.30	0.38	0.14
	Mesial root	4.63	5.11	2.11	4.48	6.80	6.93	1.21	1.48
	Distal root	4.87	5.14	1.66	2.78	6.96	7.26	1.45	2.12
	total measure	9.23	9.52	1.67	2.78	12.31	12.45	1.32	1.75

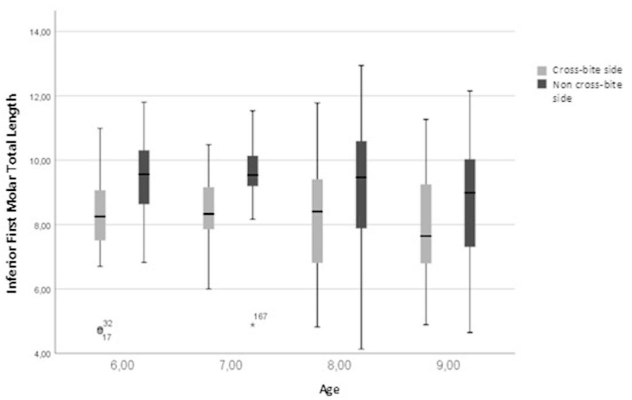

Fig. 1 Box Plot of comparison of the length of the first molar by age.

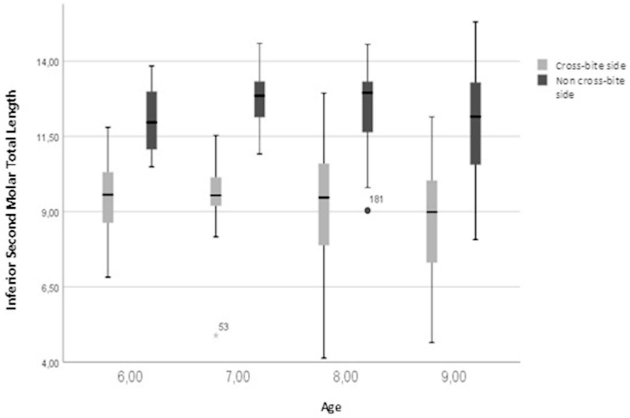

Fig. 2 Box Plot of comparison of the length of the second molar by age.

Table V. Measurement differences between the crossbite and non-crossbite side.

Differences		Mean difference	SD	Standard Error Mean	Correlation	95 % Confidence interval of the Difference		P-value	Effect Size
						Lower	Upper		
Deciduous mandibular first molar	Coronal length	-.37	.44	.041	.561	-.45	-.29	.000	-.848
	Mesial root	-.42	1.61	.15	.700	-.71	-.12	.006	-.261
	Distal root	-.27	1.09	.10	.759	-.47	-.07	.009	-.250
	total measure	-1.03	1.09	.10	.769	-1.22	-.82	.000	-.945
Deciduous mandibular second molar	Coronal length	-.44	.40	.038	.456	-.51	-.35	.000	-1.066
	Mesial root	-.51	1.03	.09	.636	-.69	-.31	.000	-.488
	Distal root	-.42	1.02	.09	.713	-.60	-.22	.000	-.406
	total measure	-1.18	.97	.09	.727	-1.36	-1	.000	-1.216
N Total					114				

DISCUSSION

The main aim was to describe the physiological resorption pattern in mandibular primary molars in children with UPCB diagnosis and to compare the deciduous root lengths on the crossbite side compared to the normal occlusion side. In order to show that the root morphology and the physiological resorption process could be modified by an altered masticatory function.

The age range of the selected sample was set to include boys and girls 6 to 9 years old, due to the resorption process for deciduous molars occurring during that period of age (Khan *et al*., 2020) as we wanted to observe how throughout this stage, the roots decrease as age (Mulia *et al*., 2018).

Radiographs were used for the observations because this is a low-cost routine complementary analysis, essential for diagnosis in pediatric dentistry, in which both jaws can be visualized (Andrade de Alencar *et al*., 2019).

Panoramic radiography is a reliable method with a 72 % accuracy, providing sufficient anatomical landmarks for the identification of different resorption stages and necessary for measuring root lengths (Murthy *et al*., 2020a), despite being a two-dimensional image that could hide resorption patterns in the buccolingual direction (Murthy *et al*., 2020a).

The advantage of this study was that all X-rays were taken at the same radiographic center, by the same specialist and with identical specifications in contrast to Bille *et al*. (2007) study whose sample was collected from different radiological centers.

Murthy *et al*. (2020a,b) classified the resorption stages into three stages: Stage 1 with 67 to 100 % root presence, Stage 2: with a presence of 34 to 66 % of root presence and, Stage 3: with 33 % or less root presence, this classification having few categories did not allow us the comparison between the side of malocclusion and normal occlusion, For this reason, he used the method described by Fanning (2008), which has 7 stages. However, in our study, the presence of atypical resorptions made their classification difficult due to their low prevalence and multiple combinations.

The exclusion of patients who had severe dental caries diagnosis, periodontal or periapical disease, orthopedic treatments or stainless steel crowns on the evaluated molars was an important aspect to consider because it may be a confounding factor, due to many of these criteria could generate chronic inflammatory processes that may hurry up the resorption process (Eronat *et al*., 2002; Sasaki, 2003; Bille *et al*., 2007).

The 86.4 % of the molars presented a predictable or linear root resorption pattern, a characteristic that coincides with the one found by Murthy *et al*.(2020b) and Peretz *et al*. (2013). No resorption stage 1 in molars (complete root) were found because the age range of the evaluated sample already showed signs of resorption (Khan *et al*., 2020).

Atypical resorption of 15 % was found, similar results to those obtained by Bille *et al*. (2007), which describes 12 % of these resorptions. Based on this study, the presence of atypical resorption cannot be associated with the malocclusion side because both sides had a similar frequency of atypical resorption. Additionally, it was observed that patients with a resorption alteration on the non-crossbite side had at least one alteration on the crossbite side.

When comparing the molar resorption stages on the crossbite side with the normal occlusion side, no statistical differences were found between both. This may be due to a possible imprecision in the resorption stages classification. In order for this to be a qualitative variable, and its assessment to be subjective, the overlap of the permanent tooth image on the deciduous root must also have to influence (Bille *et al*., 2007).

The comparison between the different age groups showed that as age increases, the mean root length of all molars decreases, these results confirm the findings of Murthy *et al*. (2020a) and Peretz *et al*. (2013).

Although no statistical differences were found during the resorption stages when the root lengths of both sides were compared. The distal and mesial roots of the molars on the UPCB side had a shorter length than on the other side. This pattern was observed in 82 % of the sample for the first molars and 88 % for the second molars.

The lack of research in this field was the main limitation, because of our results not being able to be contrasted. For this reason, it is important to promote the area of study regarding the physiological processes of resorption, its alterations and the risk factors that could cause an atypical premature loss of deciduous teeth.

CONCLUSION

Based on the results found in this study, we could affirm that root resorption stages are not altered by the presence of the UPCB. Although there was a slight increase in atypical resorption, this could not be associated with malocclusion. However, it is imperative to highlight that a shorter length of the molars was found on the crossbite side compared to their contralateral, a pattern that was repeated in 93 first molars and 100 second molars. Despite our findings, more studies are needed to corroborate our results.

ACKNOWLEDGMENTS

All authors thank to MSc. DDS Guillermo Reichard-Monefeldt for his support and advice to write this paper.

Authors' contributions

González-Cabrera: First co-author has contributed to the study concepts and design, literature research, data analysis, manuscript preparation, manuscript editing.
Ticona-Flores: Second co-author has contributed to the data analysis, statistical analysis, manuscript preparation, manuscript editing.
Diéguez-Pérez: Research director co-author has contributed to guarantor of integrity of the entire study, study concepts and design, manuscript preparation, manuscript editing.

GONZÁLEZ-CABRERA, C. ; TICONA-FLORES, J. M. & DIÉGUEZ-PÉREZ, M. Patrón de reabsorción radicular en radiografías panorámicas de pacientes pediátricos con mordida cruzada posterior unilateral: estudio transversal y retrospectivo. *Int. J. Morphol., 40(5)*:1321-1327, 2022.

RESUMEN: El trabajo de este estudio se realizó en molares mandibulares temporales en radiografías panorámicas de pacientes pediátricos con mordida cruzada posterior unilateral (MCPU). Este estudio transversal y retrospectivo analizó 114 ortopantomografías de pacientes entre 6 - 9 años de edad con diagnóstico de mordida cruzada posterior unilateral. Se analizaron los primeros y segundos molares mandibulares. Se tipificó su estado de reabsorción radicular y se midió la longitud de las raíces; para luego comparar los datos obtenidos según el lado de la maloclusión. El 86,4 % de los molares mostró un patrón de reabsorción lineal y la prevalencia de reabsorción atípica en pacientes con MCPU fue del 13,5 %. El promedio de longitud total de los primeros molares del lado de la maloclusión fue de 8,20 mm, mientras que el contralateral exhibió una media de 9,29 mm. Por último, los segundos molares tenían una longitud media de 11,12 mm en el lado de mordida cruzada y de 12,30 mm en el lado de oclusión normal. La MCPU podría afectar la reabsorción fisiológica al observar una alteración de la reabsorción en aquellos molares mandibulares ubicados en el lado de la maloclusión.

PALABRAS CLAVE: Mordida cruzada posterior unilateral; Reabsorción radicular; Maloclusión; Diente deciduo.

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