CROSS-SECTIONAL STUDY

OXIS Classification of Interproximal Contacts of Primary Molars and Its Prevalence in Three- to Four-Year-Olds

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Abstract: ***Purpose:*** *The purpose of this study was to investigate the prevalence of different interproximal contact areas of primary molars, as described in the OXIS classification, in a group of three- to four-year-old caries-free children.* ***Methods:*** *This cross-sectional study was carried out with a representative sample of 4,476 contact areas of 1,119 caries-free school children. A single calibrated examiner performed a type III examination to assess the type of contact area between primary molars, as seen from the occlusal view. The contacts were scored as O (open contact), X (point contact), I (straight contact), and S (curved contact) using OXIS classification. The prevalence of the types was expressed in the form of numbers and percentages. The findings were subjected to chi-square and McNemar's tests.* ***Results:*** *The most common contact type was I (75.5 percent), followed by S (15.3 percent), O (5.8 percent), and X (3.3 percent). Significant differences were obtained (P<0.001) when the inter-arch comparison was performed for all except the X type of contact. Further, 401 (35.8 percent) children had more than one type of contact in different quadrants.* ***Conclusions:*** *The present study highlights the existence of four different types of interproximal contact areas, O, X, I, and S, in caries-free three- to four-year-olds.* *(Pediatr Dent 2020;42(3):197-202) Received July 31, 2019 | Last Revision March 17, 2020 | Accepted March 20, 2020*

KEYWORDS: CROSS SECTIONAL STUDY, SCHOOL CHILDREN, DECIDUOUS TEETH

Contact area is a term used to denote the proximal heights of the contour of the tooth's mesial and distal surfaces. The proximal convexity of teeth creates an area of contact between adjacent teeth within the same arch.[1] A well-contoured, firm proximal contact in the permanent dentition defines the gingival embrasure and the height of the interdental papilla. A properly positioned contact is also vital to maintain the stability and integrity of the dental arches and the health of supporting structures. Thus, the significance of contact areas is well emphasized in the literature. The key prerequisite for the prevention of proximal caries is a well-established contact area that prevents food impaction.[2-5]

The existing textbooks in pediatric dentistry suggest that the contact areas between primary molars are broader, flatter, and situated farther gingivally than the contact points between permanent molars.[2-5] There is evidence to state that broad proximal contact areas seen in primary teeth are likely to increase caries susceptibility. This phenomenon could be attributed to the reduction in the mechanical cleansing action due to the limited movement between adjacent teeth, leading to greater plaque accumulation.[5,6] A review of the literature in this area revealed the presence of two types of contacts: open and closed.[7-12] In addition, all the conducted studies compared the association of open or closed contacts with dental caries.

Studies by Allison and Schwartz[7] and Subramaniam et al.[9] concluded that the risk for proximal caries in the posterior primary dentition is increased if contact points are closed rather than open. Warren et al.[10] reported that the absence of interdental spaces is weakly associated with greater decay experience in the primary dentition. Another study,[12] conducted on the progression of proximal caries, concluded that 69 percent of primary molar teeth with proximal caries developed caries on adjacent proximal surfaces and 89 percent of patients who developed a proximal caries lesion on a primary molar tooth within one quadrant developed another proximal lesion in another quadrant. A recent retrospective cross-sectional study[13] was conducted to assess the different types of interproximal contact areas of primary molars as seen from the occlusal view. The study was performed on 74 already existing cone beam computed tomography (**CBCT**) images from 28 three- to 14-year-olds and found four different types of contact areas between the primary molars (maxillary and mandibular): types O, X, I, and S, based on the shapes observed. Figure 1 denotes the criteria for the types of interproximal contacts of primary molars. The OXIS classification of contact areas was proposed following the patterns observed in the study.[13] Despite the radiographic evidence of OXIS classification, the clinical existence of the types of contact areas is yet to be documented. There is a definite need to understand the prevalence of the OXIS contacts in a population, as it might be a potential risk indicator for proximal caries.

Hence, the purpose of this cross-sectional study was to evaluate the prevalence of OXIS contact areas of primary molars in a group of three- to four-year-olds.

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HOW TO CITE:
Muthu MS, Kirthiga M, Kayalvizhi G, Mathur VP. OXIS Classification of Interproximal Contacts of Primary Molars and Its Prevalence in Three- to Four-Year-Olds. Pediatr Dent 2020;42(3):197-202.

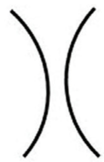
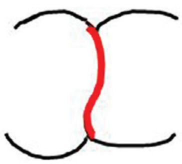
Sl no.	Diagrammatic representation	Criteria	Type of contact
1		When there is no contact between the primary molars.	Open contact
2		When there is a point of contact (</=1.5 mm) between the primary molars.	X-shaped contact
3		When there is a straight contact (>/= 1.5 mm) between the primary molars.	I-shaped contact
4		When there is a curved contact between the primary molars.	S-shaped contact

Figure 1. Scoring criteria for the types of interproximal contacts of primary molars.

Methods

Ethical aspects. This study was approved by the Institutional Ethics Committee, Sri Ramachandra Institute of Higher Education and Research, Chennai, Tamil Nadu, India. Permission from the chief educational officer of Puducherry, India, and the principals of the respective schools was sought before beginning the study. In addition, individual parental consent was also obtained for those children involved in the study.

Study population. A population-based cross-sectional study was conducted involving three- to four-year-olds who had an ancestral nativity in Puducherry. According to the 2011 census, the city has an estimated population of 1,247,953, including 132,858 children (zero to six years old). Puducherry is a Union Territory divided into five zones, with 113 private schools and 161 government schools with children ranging in age from three to four years old, according to the Directorate of School Education, Government of Puducherry.

Sampling strategy. An equal number of children was selected from all the five zones for an overall representation. A two-stage sampling procedure was used. In the first stage, an equal number of government and private schools were selected by simple random sampling (lottery method), such that every school had an equal opportunity to be included from each zone. In the second stage, an equal number of children was selected from each zone from the already selected schools using simple random sampling.[14] The distribution of the sample was proportional to the population enrolled at government and private schools (45.0 percent and 55.0 percent, respectively).

Sample size. The sample size was calculated using nMaster 2.0 software (Department of Biostatistics, CMC, Vellore, Tamil Nadu, India). The variables used were 9.4 percent prevalence rate of open (O) type of contacts from a previous study,[13] 95 percent confidence interval, and precision as 10 percent of prevalence (0.94 percent). The minimum sample size was determined as 4,076 contacts or 1,019 children (four contacts for each child). Thus, considering a 90 percent response rate (those willing to participate in the study), the final sample was fixed at 4,476 contacts of 1,119 children.

Selection criteria. Three- to four-year-olds with a caries-free dentition (ICDAS score of zero and never experienced caries in the past), who cooperated in the generation of impressions and whose parents provided consent, were

Table 1. PREVALENCE AND PERCENTAGES OF PRIMARY MOLAR CONTACTS BY GENDER, ARCH AND SIDE

Type of contact	Maxilla (N=2,238)						Mandible (N=2,238)						Overall		*P*-value*
	Right side (N=1,119)		Left side (N=1,119)		Total	%	Right side (N=1,119)		Left side (N=1,119)		Total	%	Total	%	
	M	F	M	F			M	F	M	F					
O	51	40	49	52	**192**	8.6	10	26	10	23	**69**	3.1	**261**	**5.8**	<0.001*
X	15	20	20	25	**80**	3.6	17	16	19	16	**68**	3.0	**148**	**3.3**	0.296
I	361	410	368	399	**1538**	68.7	456	465	454	468	**1843**	82.4	**3381**	**75.5**	<0.001*
S	123	99	113	93	**428**	19.1	67	62	67	62	**258**	11.5	**686**	**15.3**	<0.001*
Gender vs. right maxilla: χ^2=7.432, *P*=0.059; gender vs. left maxilla: χ^2=9.559, *P*=0.655.															
Gender vs. right mandible: χ^2=7.103, *P*=0.069; gender vs. left mandible: χ^2=5.464, *P*=0.141.															

* χ^2=chi-square value; *P*<0.05=significant. This was the inter-arch comparison performed for each type of contact specifically. This was performed between arches i.e. maxilla and mandible. The relevance of the significant difference is that the rate of occurrence of the contact is significantly greater in the mandible when compared with the maxilla. This significant difference was present for all the types of contacts except the X type.

included. Children with special needs and those who showed the presence of developmental anomalies of the shape of their teeth were excluded from the study.

Training and calibration of the examiner. Before the start of the study, a single pediatric dentist was extensively trained and calibrated under the supervision of an expert to clinically evaluate the contact areas over two months duration. The session consisted of a calibration process of 10-hour duration in two separate stages. The session included slide presentations with clinical photographs of the OXIS classification of contact areas[13] to be observed clinically. In the second stage, a clinical exercise using 100 study models of 25 children was performed to provide a learning environment of previously acquired theoretical information. In the last stage, examination and re-examination of the same 25 children after two weeks was completed by the examiner. The kappa value obtained was 0.96, which reflected a high degree of agreement.

Clinical examination. Clinical examinations were performed at schools following all precautions to prevent cross-infection among participants by the previously calibrated well-trained examiner, with satisfactory kappa coefficients. They were conducted in a suitable classroom using a mouth mirror and probe under natural light (Type III examination). Cotton rolls were used to clean the teeth of food debris and dry them. In addition to the clinical examination, sectional maxillary and mandibular impressions were poured up to produce die models for record purposes for a prospective cohort study planned for the future. The next section was the assessment of the contact area between the distal surface of the primary first molar and the mesial surface of the primary second molar in both arches. The contact observed was scored in the form of O (open contact), X (point contact), I (straight contact), and S (curved contact) or others (if there was a different shape), as seen from an occlusal view.[13] The closed/open nature of the contact was assessed using dental floss in the contact areas. If resistance was felt in a contact area, it was scored according to the shape mentioned previously. If there was no resistance, the contact area was scored as open. The data were extracted for all included children using a custom-made data extraction sheet.

Statistical analysis was performed using SPSS 19.0 software (SPSS, Chicago, Ill., USA). The data were recorded on a custom-made data extraction sheet. Descriptive statistics were obtained for all variables. The prevalence of the types of contact areas was expressed in the form of numbers and percentages. The numerator in every case was the number of each type of contact—namely O, X, I, or S. The denominator was 2,238 in the case of each arch (maxilla or mandible) and 4,476 contacts for the overall total calculation. The chi-square test was applied to determine the association of contact areas in each quadrant across genders. McNemar's test was used to assess the intra- and interarch variability. A P-value of less than 0.05 was deemed to indicate statistical significance. Mixed effects model-negative binomial distribution was performed considering school as the hierarchical level to adjust for the clustering effect induced by the two-stage sampling method. Intra-examiner variability was evaluated through percentage agreement and Cohen's kappa statistics.

Results

A total number of 1,119 mothers of caries-free children agreed to participate in the study. The total number of children screened to reach the required sample size was 1,585 and the caries prevalence of the study population was found to be 29.5 percent.

Prevalence and percentages. An almost equal distribution was reached concerning the gender of the 1,119 children included in the study: 550 were males, and 569 were females. The mean age of the participants was 3.5 years old. The number of children selected from government and private schools was 498 and 621, respectively. Table 1 summarizes the prevalence and percentages of contacts in between the primary molars according to the arch, side, and gender. The prevalence of the O type of contact was 5.8 percent: 5.7 percent on the right side versus 6.0 percent on the left side (P=0.65), 8.6 percent in the maxilla versus 3.1 percent in the mandible (P<0.001). The prevalence of the X type of contact was 3.3 percent: 3.0 percent on the right side versus 3.6 percent on the left side (P=0.317), 3.6 percent on the maxilla versus 3.0 percent on the mandible (P=0.296). The prevalence of the I type of contact

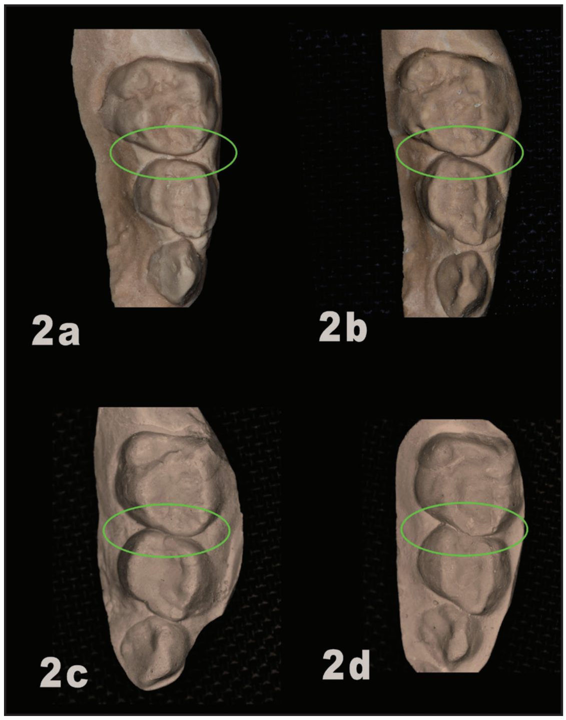


Figure 2. Respresentative sectional stone model of contact areas of primary molars in the maxilla. (a) Depicting "O" or open type of contact. (b) Depicting "X" or point type of contact. (c)Depicting "I" or straight type of contact. (d) Depicting "S" or curved type of contact.

Table 2. INTERARCH AND INTRA-ARCH COMPARISONS (P-VALUE) WITHIN INDIVIDUALS*

Type of contact	Maxillary vs. mandibular (right side)	Maxillary vs. mandibular (left side)	Right vs. left side (maxilla)	Right vs. left side (mandible)
O	<0.001*	<0.001*	0.312	0.607
X	0.526	0.532	0.791	0.791
I	<0.001*	<0.001*	0.728	1.000
S	<0.001*	<0.001*	0.405	1.000

* P<0.05=significant; McNemar's Test.

was 75.5 percent: 75.6 percent on the right side versus 75.5 percent on the left side (P=0.92), 68.7 percent in the maxilla versus 82.4 percent in the mandible (P<0.001). The prevalence of the S type of contact was 15.3 percent: 15.7 percent on the right side versus 15.0 percent on the left side (P=0.509), 19.1 percent in the maxilla versus 11.5 percent in the mandible (P<0.001).

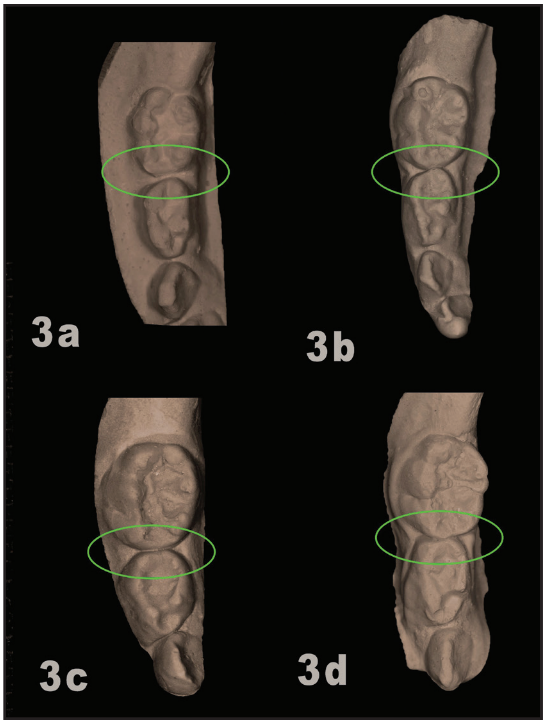


Figure 3. Representative sectional stone model of contact areas of primary molars in the mandible. (a) Depicting "O" or open type of contact. (b) Depicting "X" or point type of contact. (c) Depicting "I" or straight type of contact. (d) Depicting "S" or curved type of contact.

Table 3. MIXED EFFECTS MODEL CONSIDERING SCHOOL AS THE HIERARCHICAL LEVEL

Variables	Model 1	
	IRR (95% CI)*	*P*-value†
Type of arch		
Maxilla	1.03 (0.95,1.13)	0.479
Mandible	1.00	
Right side	0.99 (0.91,1.08)	0.878
Left side	1.00	
Gender		
Male	1.01 (0.92,1.10)	0.885
Female	1.00	
Type of contact		
I	9.72 (8.02,11.77)	**<0.001**
O	1.33 (1.06,1.67)	**0.015**
S	2.55 (2.08,3.13)	**<0.001**
X	1.00	
2log-likelihood ratio	3114.09	

* IRR=incidence rate ratio; CI=confidence interval.

† Bold values are P<0.05=significant. Likelihood ratio test is the name of the test.

Frequency of contacts. Among the different types of contacts (Figure 2), the most common contact in the maxilla was observed as I (68.7 percent), followed by S (19.1 percent), O (8.6 percent), and X (3.6 percent). In the mandible (Figure 3), the most common contact type was I (82.4 percent) followed by S (11.5 percent), O (3.1 percent), and X (three percent), respectively. Overall, the most common contact was I (75.5 percent), followed by S (15.3 percent), O (5.8 percent), and X (3.3 percent).

Similarity of contacts. In the present study, 64.2 percent of the children were found to have the same contact in all four quadrants. Among them, 17 (1.5 percent) had the O type, five (0.5 percent) had the X type, 638 (57.1 percent) had the I type, and 58 (5.1 percent) had the S type of contact in all four quadrants. The remaining 401 children (35.8 percent) had more than one type of contact in different quadrants either between or within arches. When the arches were considered individually, 92.5 percent of the contacts in the maxilla and 97.1 percent in the mandible had similar contacts on the right and left sides, respectively.

Intra-arch, interarch, and gender comparison. When the intra-arch comparison (right side versus left side) was performed for the same individual, there was no significant difference found with any of the contacts (Table 2). When the interarch comparison (maxilla versus mandible) was performed for the same individual, there was a significant difference (P<0.001) regarding O, I, and S types of contact on the right and left sides (Table 2). The authors also evaluated the overall interarch comparison concerning the specific type of contact. All the contacts were found to be significant individually between arches, except the X type of contact (P=0.296; Table 1). However, no significant associations were found when gender was compared with individual quadrants (Table 1).

Mixed effects model. Data were analyzed in the form of a mixed-effects model to adjust for the clustering effect. Data point was fit to follow a negative binomial distribution instead of Poisson distribution due to its over dispersed nature. Results of the mixed effects model (Table 3) revealed a statistically significant output for the type of contact associated with the incidence rate ratio (**IRR**) adjusting for the clustering effect of the school. However, other variables in the model did not demonstrate a statistically significant association. When the type of contact was considered, IRR was highest for the I shaped contact [IRR 9.72; 95% CI (8.02-11.77)], followed by S type (IRR 2.55; 95% CI (2.08-3.13), and finally O (IRR 1.33; 95% CI (1.06-1.67) when compared with the X type contact. The model selection was decided by the 2log-likelihood ratio. 2log-likelihood ratio is a statistical ratio determined from a log-likelihood ratio test which is used to compare the goodness of fit of two models. The variance after adjusting at the school level is 0.44 (±0.12 standard error).

Discussion

The present epidemiological study clinically validates Kirthiga and Muthu's OXIS classification of contact areas[13] in primary molars. Also, the prevalence and distribution of OXIS contacts within the arches were studied. This is the first epidemiological study that evaluated the specific types of contact areas. There was only one study previously conducted in this area.

This study evaluated the types of noncarious interproximal contact areas of primary molars in children using existing CBCT images. In addition, this study inferred that the contact area was predominantly present at the occlusal level, which is contradictorywith the traditional notion of the contact areas being broad, flat, and situated further gingivally. However, this finding also indicated that a clinical examination would be adequate to evaluate the types of contact areas.[13] This report laid the scientific foundation for the present study.

The present study used OXIS criteria to score the contact areas of primary molars from the occlusal view.[13] Previous studies[9,10] used different criteria, which were not employed in the present study since they classified only the open/closed nature and not the specific type of contact. Nevertheless, the open and closed nature of the contact was assessed in the present study using dental floss.[7] The percent of closed contacts in the present study was 94.1 percent. This finding confirmed those of other studies conducted by Kirthiga et al.[13], Subramaniam et al.[9], and Allison and Schwartz[7], where 90.5 percent, 90 percent, and 84 percent were found, respectively. The most and least common contact areas in the present study observed in the maxilla were I (68.7 percent) and X (3.6 percent), respectively. However, in the mandible, the most common and least common contact areas were I (82.4 percent) and X (3.0 percent), respectively. Overall, the most and the least common contact areas were I (75.5 percent) and X (3.3 percent), respectively.

Compared to a previously conducted study,[13] the present study was in agreement regarding the most common contact but was opposite concerning the least common contact. This finding could be attributed to the significant difference in the sample size, which consisted of 4,476 contacts in the present study versus 74 contacts performed with CBCT images. Although there was a provision in the data extraction form for a shape other than OXIS,[13] none were observed in the present study. It is noteworthy to mention that the prevalence of the O type of contact was 8.6 percent in the maxilla, almost evenly distributed between genders. By contrast, 3.1 percent of the O type of contacts was observed in the mandible, with females having more than twice open spaces than males. However, this could not be compared to other studies due to a lack of previous data available in the literature. Further research is needed to understand the reason for this occurrence.

When the interarch comparison was performed, significant findings ($P<0.001$) were obtained. However, no significant findings were observed regarding gender. These findings could not be compared, as there is no previous data on the prevalence of the contact areas.

An interesting result of this study was that 401 (35.8 percent) of the children had more than one type of contact in different quadrants. The most common contact present in all four quadrants was I, present in 638 children. Concerning the authors' findings, identical contacts were present in 92.5 percent and 97.1 percent on the right and left sides of the maxilla and mandible, respectively.

This study had both strengths and limitations. This is the first epidemiological study that assessed the type of contact areas in primary teeth. Another strength is the large sample size of 4,476 contacts among 1,119 children, with an overall representation from all the five zones. In addition, impressions were made for all the included children. Hence, the models served as records for future reference (a cohort study to assess the risk of caries for the type of contact area).

In terms of limitations, it is important to emphasize that, in the present study, a single examiner performed the clinical examinations of all the included children Additionally, due to the lack of studies that used a similar methodology, it was not possible to compare this study's data. Another limitation is that the findings cannot be generalized to other racial/ethnic groups. Further studies should be performed in individual racial/ethnic groups to confirm these results.

Based on the morphology of the types of contact areas in the present study, it is logical to postulate that the I- and S-type contact areas might lead to greater plaque accumulation than the O- and X-types. The inaccessibility of these contact areas could lead to more plaque accumulation and difficulty in maintaining oral hygiene. This phenomenon could further increase the risk of dental caries for the teeth in contact. There are three significant clinical implications for the type of contact area. First, an understanding of the proximal contact area in a three-dimensional context has increased the need for this to be considered as a potential risk factor for caries risk assessment. Second, the change in the type of contact area (open or closed) may also influence the cavity preparation in primary molars, especially in class II preparations. For instance, the proximal box preparation would be be minimal for an X or O type of contact. However, the same preparation could be challenging in an I or S type of contact because of its broad nature. The original type of contact must be re-established following the insertion of a restoration or stainless steel or zirconia crown. Third, the contact between two primary teeth could vary following the insertion of a stainless steel crown in one of the teeth compared to the initial contact.

Therefore, future studies should focus on the prevalence of contact areas of primary molars in different ethnic populations using the standardized methodology. In addition, long-term prospective studies are also required to evaluate the association of the types of contact areas of primary molars with the occurrence of early childhood caries and the changes observed in the contact areas after the insertion of a stainless steel crown.

Conclusions

Based on this study's results, the following conclusions can be made:

1. Although the OXIS classification[13] was established using cone beam computed tomography images of 29 three- to 14-year-olds, this study validates the data on three- to four-year-olds.
2. The present study highlights the existence of four different types of interproximal contact areas in caries-free children, namely O, X, I, and S, which is in accordance with OXIS classification.[13]
3. Among the four types of contacts, the most common type is I (75.5 percent).
4. The S- and I-type of contacts could be the most susceptible to proximal caries owing to its broad nature, greater plaque retention and inaccessibility to mechanical cleaning.
5. Among the children studied, 64.2 percent showed the same contact in all the four quadrants.
6. The prevalence of OXIS contacts need to be confirmed in various ethnic populations in the future.
7. Future studies are also required to evaluate the caries susceptibility of the specific types of contacts.

Acknowledgment

The authors wish to thank Dr. Kavitha M, MDS, Senior Lecturer, Department of Pedodontics and Preventive Dentistry, Indira Gandhi Institute of Dental Sciences, Puducherry, India; Dr. Sujitha Ponraj, BDS and Dr. Bhavyaa R, BDS, post graduate students, Department of Pediatrics and Preventive Dentistry, Faculty of Dental Sciences, Sri Ramachandra Institute of Higher Education and Research, Chennai, Tamilnadu, India; and Dr. Ericsson Spurgeon, intern, Faculty of Dental Sciences, Sri Ramachandra Institute of Higher Education and Research, Chennai, Tamilnadu, India, for their assistance in the process of screening school children.

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