Oral Health Status of Children with Syndromic Craniosynostosis

Gisele da Silva Dalben[a]/Beatriz Costa[b]/Marcia Ribeiro Gomide[b]

Objective: To gain more information on the oral health status of subjects with syndromic craniosynostosis.

Design: A cross-sectional study.

Materials and Methods: The present study took place at the Hospital for Rehabilitation of Craniofacial Anomalies of University of São Paulo (HRAC-USP). The sample was 19 patients with syndromic craniosynostosis (10 Apert, 5 Crouzon, 2 Pfeiffer and 2 Saethre-Chotzen), aged 5 to 15 years. An assessment of plaque, caries and gingival indices, and evaluation of the efficacy of toothbrushing was carried out. The measurements included PHP index, dmft and DMFT indices, gingival index, comparison of PHP before and after non-supervised toothbrushing and between individuals with and without severe syndactyly.

Results: The patients displayed high plaque index and poor efficacy of toothbrushing, regardless of the presence of severe syndactyly; despite the plaque accumulation, the gingival index was not proportionally high. There was predominance of the D component for the DMFT index, which combined with the need for restorative treatment in 42.1% of the patients indicates poor access to dental care by these patients.

Conclusions: The results show the need for a dental follow-up programme for these patients. Carers should be informed of the importance in aiding these patients during accomplishment of oral hygiene at home.

Key words: acrocephalosyndactylia, craniofacial dysostosis, craniosynostosis dental plaque index, DMF index, periodontal index, mouth breathing, toothbrushing

Oral Health Prev Dent 2006; 4: 173–179. *Submitted for publication: 29.06.05; accepted for publication: 01.12.05.*

The term craniosynostosis refers to early closure of cranial sutures; at birth, cranial bones are separated from each other, yet firmly connected by the sutures. Intensive bone formation occurs at the margin of sutures, which allows cranial growth. This is directly related to brain growth and is remarkable during the first two years of life. Premature closure of one or several cranial sutures leads to a reduction in bone synthesis, ultimately giving rise to craniofacial deformities. Moreover, it may also yield neurological problems due to restricted brain growth, if not properly treated. Craniosynostoses may be classified as simple or multiple according to the number of sutures affected; as primary or secondary according to their etiology; and finally, as non-syndromic or syndromic according to the association with other malformations (Cranioestenose, 2002).

The syndromes most frequently associated with craniosynostoses are the Apert and Crouzon syndromes; other craniosynostosis syndromes include the Pfeiffer, Saethre-Chotzen, Carpenter, Jackson-Weiss and cloverleaf skull syndromes (Gorlin et al, 1990).

The Apert, Crouzon, Pfeiffer and Saethre-Chotzen syndromes present autosomal dominant inheritance assigned to mutations in the FGFR2 gene at locus 10q26 (Zanini, 2000). The premature fusion of cranial

[a] *Public Health Dentistry Sector, Hospital for Rehabilitation of Craniofacial Anomalies, University of São Paulo, Bauru, SP, Brazil*

[b] *Pediatric Dentistry Sector, Hospital for Rehabilitation of Craniofacial Anomalies, University of São Paulo, Bauru, SP, Brazil*

Reprint requests: *Gisele da Silva Dalben, Setor de Odontologia em Saúde Coletiva / HRAC-USP, Rua Silvio Marchione, 3-20 – Vila Universitária, 17043-900, Bauru, SP, Brazil. Tel: +55 (14) 3235-8141; Fax: +55 (14) 3234-7828; Email: gisdalben@centrinho.usp.br*

sutures has been related to gene-activated premature apoptosis of mature osteoblasts in patients with Apert syndrome (Lemmonier et al, 2001) and to different expression of cytokines and extracellular matrix macromolecule accumulation in individuals with Apert and Crouzon syndromes (Carinci et al, 2000); the mineral metabolism of these patients has not been investigated so far and should be the subject of future studies. The phenotypic craniofacial aspects of these syndromes are similar, and diagnosis is primarily based on limb deformities, which differ for each syndrome, with severe syndactyly of the 2nd, 3rd and 4th digits in Apert syndrome, broad halluces in Pfeiffer syndrome, soft tissue syndactyly and clinodactyly in Saethre-Chotzen syndrome, and no limb alterations in Crouzon syndrome. In addition to these aspects, these patients usually present exophthalmos, ocular hypertelorism and hypoplastic midface with Class III malocclusion, especially for the Apert and Crouzon syndromes, besides systemic alterations.

The oral characteristics of Apert syndrome include high and deformed palate (Salinas, 1982; Ferraro, 1991), disturbances in tooth eruption, which is worsened in older patients (Kaloust et al, 1997), ectopic tooth eruption (Rynearson, 2000; Kreiborg and Cohen Junior, 1992), gingival hypertrophy (which may also impair tooth eruption), multiple tooth agenesis (Schudy, 1986; Ferraro, 1991; Kreiborg and Cohen Junior, 1992), shovel-shaped incisors (Kreiborg and Cohen Junior, 1992) and apparent macroglossia (Sonnenberg et al, 1977). There is thickening of the alveolar ridge to allow arrangement of the impacted and severely crowded teeth (Sonnenberg et al, 1977; Ferraro, 1991).

With regard to the oral health status of patients with Apert syndrome, high caries prevalence has been reported, with early loss of teeth and difficult oral hygiene control related to the limb malformations (Paravatty et al, 1999).

O'Donnell (1985) highlighted the need of early intervention in patients with Crouzon syndrome, especially from an aesthetic perspective, with a view to increasing the patient's interest in him or herself. These patients were believed to present mental retardation, which is not true, and the apparent retardation may be more social than mental. It is reported that the appearance of these individuals often makes them 'socially unacceptable', preventing them from having a normal social interaction (Turvey et al, 1979).

The only investigation in the literature regarding the oral health status of these patients was conducted by Mustafa et al (2001). These authors examined 57 children with craniosynostosis (11 with Apert syndrome, 21 with Crouzon syndrome, 5 with Pfeiffer syndrome, 3 with Saethre-Chotzen syndrome and 17 with non-syndromic craniosynostosis), aged 3 to 16 years, who were compared with a control group matched for gender, age and ethnicity, by evaluation of the dmft, DMFS and DMFT indices, amount of dental plaque, gingivitis and enamel defects, besides microbiological evaluation. The results demonstrated a higher frequency of caries-free children in the study group, with a higher dmft index for the control group, which the authors assigned to the fact that children in the study group attended a multidisciplinary clinic since early childhood. Children with craniosynostosis displayed larger amounts of plaque, related by the authors to difficult oral hygiene control because of dental crowding, and thus the authors highlighted the importance of regular professional prophylaxis. The study group exhibited higher frequency of gingivitis in permanent teeth. Both groups demonstrated similar outcomes with regard to enamel defects and microbiological evaluation.

Most investigations available on syndromic craniosynostosis are related to the genetic aspects or surgical approach for such disturbances, with little emphasis on the oral aspects. Thus, this study investigated the oral health status of these patients by analysis of plaque, caries and gingival indices, besides assessment of efficacy of toothbrushing and comparison of this efficacy according to the presence or absence of severe syndactyly, in a group of subjects with syndromic craniosynostosis.

MATERIALS AND METHODS

All patients with Apert, Crouzon, Pfeiffer and Saethre-Chotzen syndromes assisted at the Hospital for Rehabilitation of Craniofacial Anomalies (HRAC/USP) were identified by search on the hospital database. The initial exclusion criterion was based on age range, from 5 to 15 years old, to achieve a sample of children and teenagers. Children aged less than 5 were not included because of their inability to carry out effective toothbrushing on their own. Individuals previously submitted to orthodontic or orthognathic treatment were also excluded, since they might have undergone serial tooth extraction that could have eliminated tooth crowding, which in turn is a risk factor in plaque accumulation. Other individuals had died prematurely, had received definitive discharge from the hospital, abandoned the treatment, did not comply with the examination, were lacking definitive diagnosis of the syndromes or did not attend the hospital during the study period.

A sample of 19 patients with syndromic craniosynostosis was finally achieved: 10 with Apert syndrome, 5 with Crouzon syndrome, 2 with Pfeiffer syndrome and 2 with Saethre-Chotzen syndrome. The parents/guardians of all patients were informed of the purposes of the study and signed an informed consent form. The study design had been previously approved by the Ethics Committee of HRAC/USP.

Clinical examination of all subjects was conducted by a single examiner. Caries prevalence was investigated by the dmft and DMFT indices, following the criteria established by the World Health Organization (1997), with a CPI probe while on a dental chair, under artificial light and after air-drying to allow better observation of teeth. Accumulation of plaque was assessed by the Patient Hygiene Performance (PHP) index (Podshadley and Haley, 1968). Dental plaque was stained with malachite green. The gingival index (GI) was calculated as suggested by Löe (1967).

Evaluation of the PHP index in the patients was performed at two different periods, before (T1) and after (T2) non-supervised toothbrushing, for assessment of the efficacy of plaque control. All patients used the same type of toothbrush and dentifrice. All patients with Apert syndrome were regarded as having severe syndactyly, except for one girl who presented mild syndactyly and had undergone successful surgical repair. The group without severe syndactyly included this girl and all patients with Crouzon, Pfeiffer and Saethre-Chotzen syndromes. Thus, the efficacy of toothbrushing was compared between patients with (9 patients) and without (10 patients) severe syndactyly, to determine whether this malformation impaired handling of the toothbrush.

After examination, the patients received professional prophylaxis and oral hygiene instructions, besides information on their oral health status. Patients in need of restorative treatment were scheduled for treatment at the HRAC-USP or referred to dental treatment at their cities of origin, as preferred by the family.

Calibration procedures were performed before onset of the study for evaluation of intra-examiner agreement on the indices. With regard to the dmft and DMFT indices, 10 random patients undergoing dental treatment at the Pediatric Dentistry clinic of HRAC-USP were examined. The first evaluation was conducted after one session of dental treatment, and the second evaluation was performed before the following session, so that there were no alterations in the patient's dental status between both examinations. The time interval between the first and second evaluations was no longer than 24 hours. Overall, the 10 patients presented 214 teeth that were considered individually for calculation of the kappa coefficient of agreement, which revealed a value of 0.88 ($p = 0.04$).

Concerning the PHP index, it was not possible to perform two distinct examinations in a single patient, since this index is highly variable after a meal or toothbrushing. Thus, digital photographs were achieved from 33 dental surfaces stained with malachite green, and the first and second evaluations were performed by observation on the computer screen with a 48-hour interval between them. The agreement achieved was 0.81 ($p = 0.11$).

No procedure could be performed for evaluation of intra-examiner agreement on the gingival index, which is also highly variable and does not allow photographic evaluation. Instead, the examiner was trained by a professional experienced in the use of this index.

The caretakers were asked about the presence of mouth breathing and the patients' records were evaluated to confirm such information, for later correlation between the type of breathing and the gingival index, and observation of its influence on gingival health. Information on the mental development of these patients was also investigated on the patients' records.

Data were evaluated by descriptive statistics and statistical analysis by non-parametric tests.

RESULTS

The sample was composed of 9 females and 10 males; the mean age was 9.5 years (range 5 to 14 years, standard deviation 2.6 years). Information on the number of teeth and dental stage of each patient is presented in Table 1.

The stage of mental development and learning ability of all patients were considered normal according to the psychology records. All children attended regular schools in grades compatible with their ages.

The values found for the PHP index for the total sample and for groups with and without syndactyly are displayed in Table 2. The reduction in plaque index achieved by the whole group was statistically significant (Wilcoxon test, $p = 0.0001$).

There was no statistically significant difference in the PHP index between groups with and without syndactyly (Mann–Whitney test, $p = 0.50$). The relationship between plaque reduction (difference in PHP between T1 and T2) and the presence or absence of syndactyly was not significant (Mann–Whitney test, $p = 0.12$). No statistical differences were observed in the PHP index between the anterior and posterior regions in total (4.05 and 3.94, respectively; Wilcoxon test, $p = 0.64$).

Table 1 Age, gender, number of erupted teeth and dental stage of all patients in the sample

Patient	Age (month)	Gender	Syndrome	Syndactyly	Deciduous teeth	Permanent teeth	Total number of erupted teeth	Dental stage
1	100	M	Crouzon	No	12	8	20	early mixed
2	95	M	Crouzon	No	11	11	22	early mixed
3	67	F	Pfeiffer	No	20	2	22	early mixed
4	117	M	Pfeiffer	No	12	11	23	early mixed
5	116	F	Apert	Yes	6	12	18	late mixed
6	96	M	Apert	Yes	15	8	23	early mixed
7	154	M	Crouzon	No	0	19	19	permanent
8	154	M	Apert	Yes	0	26	26	permanent
9	136	F	Apert	Yes	0	25	25	permanent
10	82	F	Apert	No	17	3	20	early mixed
11	74	M	Crouzon	No	18	6	24	early mixed
12	95	F	Apert	Yes	16	2	18	early mixed
13	170	F	Apert	Yes	2	18	20	late mixed
14	61	M	Crouzon	No	20	2	22	early mixed
15	151	M	Saethre-Chotzen	No	0	28	28	permanent
16	85	F	Apert	Yes	16	4	20	early mixed
17	130	M	Apert	Yes	4	18	22	late mixed
18	79	F	Saethre-Chotzen	No	15	8	23	early mixed
19	101	F	Apert	Yes	12	6	18	early mixed

M, male; F, female

Table 2 PHP values for the total sample and for the groups with and without syndactyly

	Period	Mean ± SD	Mean difference between T1 and T2	Variance	Median
Total sample	T1	4 ± 0.66	1	3–5	4
	T2	3 ± 0.88		1–4	3
With syndactyly	T1	4 ± 0.88	1	3–5	4
	T2	3 ± 0.7		2–4	3
Without syndactyly	T1	4 ± 0.66	1	3–5	4
	T2	3 ± 1.05		1–4	3

SD, standard deviation; T1, before toothbrushing; T2, after toothbrushing

Descriptive statistics on the dmft and DMFT indices for the whole group and for the groups with and without syndactyly are displayed in Table 3 and Figure 1. There was no significant relationship between the dmft and DMFT indices and the PHP index (Spearman coefficient of correlation, p = 0.74 and p = 0.90 respectively). Despite the difference in absolute numbers in the dmft and DMFT indices between groups with and without syndactyly (Table 3), this was not statistically significant for both indices (Mann–Whitney test, p = 0.11 and p = 0.06 respectively).

The values found for total GI and those according to the tooth aspect and mouth region are displayed in Table 4.

There was a statistically significant difference in GI according to the tooth aspect, being higher for mesial

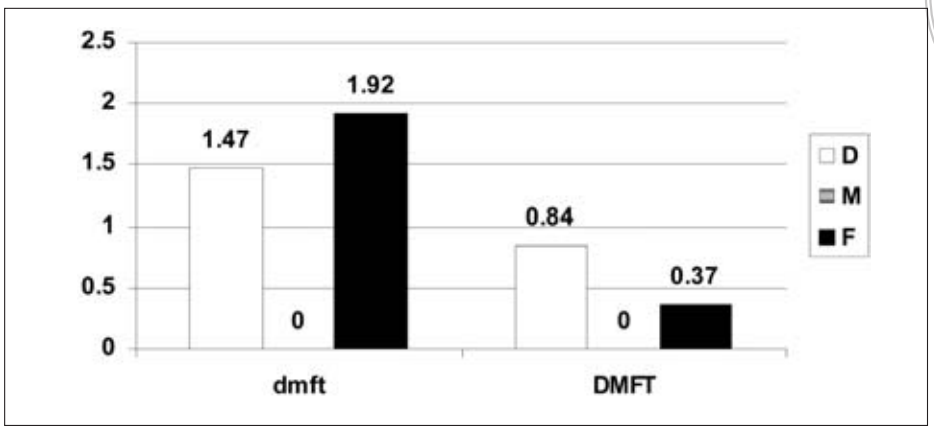

Fig 1 Mean of each component of the dmft and DMFT indices

Table 3 Mean dmft and DMFT values for the total sample

	Index	Mean ± SD
Total sample	dmft DMFT	3.40 ± 4.15 1.21 ± 2.55
With syndactyly	dmft DMFT	4.70 ± 4.85 1.60 ± 2.60
Without syndactyly	dmft DMFT	2.30 ± 3.37 0.80 ± 2.52

SD, standard deviation

Table 4 Mean total GI and GI according to tooth aspect and mouth region

		Mean ± SD	Median
Total GI		0.84 ± 0.37	1.00
With syndactyly		1.00 ± 0.26	0.67
Without syndactyly		0.70 ± 0.24	0.57
Aspect	Buccal	0.68 ± 0.58	1.00
	Lingual or palatal	0.68 ± 0.47	1.00
	Mesial	0.94 ± 0.40	1.00
	Distal	0.94 ± 0.40	1.00
Region	Anterior	0.94 ± 0.22	1.00
	Posterior	0.68 ± 0.47	1.00

SD, standard deviation

and distal aspects compared with buccal and lingual or palatal aspects (non-parametric Friedman test, p = 0.02). With regard to region, the GI of the anterior region was statistically higher than that of the posterior region (Wilcoxon test, p = 0.02). A statistically significant difference was observed in GI between groups with and without syndactyly (Mann–Whitney test, p = 0.04), being higher for the group with syndactyly (Table 4). There was no significant relationship between GI and PHP (Spearman coefficient of correlation, p = 0.36).

All patients were predominantly mouth breathers according to the parents' reports and ENT and Speech Therapy records; therefore the relationship between total GI and presence of mouth breathing was not statistically evaluated.

DISCUSSION

The reduction in dental plaque achieved by non-supervised toothbrushing was statistically but not clinically significant, since the index was still high after toothbrushing (Table 2). The non-statistically significant difference in plaque reduction observed between patients with and without syndactyly is in disagreement with other authors (Paravatty et al, 1999) and possibly indicates that individuals with syndactyly become adapted to their condition, finding ways to accomplish their daily tasks and achieving similar abilities to those of individuals without limb malformations.

Despite the high plaque index, the dmft and DMFT indices were not proportionally high (3.4 and 1.21 respectively). The lack of a significant relationship between the dmft and DMFT indices and the PHP index may have been influenced by the sample size or could be a result of salivary features, which were not addressed in the present study; this aspect should be further investigated in future studies. An important finding was the predominance of the D component for the DMFT index; the higher proportion of decayed rather than treated teeth in the index may indicate poor access to dental care by these patients.

The absence of statistical significance with regard to the dmft and DMFT indices between the groups with and without syndactyly, despite the absolute difference (Table 3), may have been influenced by the small sample size. The similar plaque index and efficacy of toothbrushing of both groups are also not in agreement with this absolute difference.

A similar observation of a high plaque index associated with a low caries index was previously reported by Mustafa et al in 2001. However, these authors grouped children with syndromic and non-syndromic craniosynostosis, and the latter represents a very distinct group, which may have accounted for the results observed. The study by Mustafa et al (2001) also used microbiological evaluation, which revealed similar outcomes for both study and control groups. Considering these findings, the authors assigned the low caries index in the study group to the regular dental follow-up offered in a multidisciplinary clinic to the children with craniosynostosis included in their sample. However, this is not true for the patients of the present study, who only attended the dental clinic upon the request of the patient or carers or as a result of referral from the craniofacial surgeons. Therefore this observation of high plaque index associated with low caries index remains unexplained.

The finding of a statistically significant difference in GI between the groups with and without syndactyly (Table 4), despite the similar plaque index, may have been influenced by the deposits of mucopolysaccharides observed in patients with Apert and Crouzon syndromes, related to the typical soft tissue lateral palatal swellings (Solomon et al, 1973), since the group with syndactyly comprised only children with Apert syndrome and the other group combined Crouzon and the other syndromes. However, investigations on larger samples are required to corroborate this assumption.

The statistically higher GI on the mesial and distal aspects compared with the buccal and lingual or palatal aspects ($p = 0.02$) probably reflects the more difficult hygiene control on these surfaces, possibly related to difficulties in flossing. The statistically higher GI for the anterior region, despite the similar amount of plaque of the anterior and posterior regions, may have been influenced by the mouth breathing presented by these patients, in agreement with other authors, who demonstrated increases in the GI in mouth breathers regardless of the accumulation of plaque (Jacobson, 1973; Wagaiyu and Ashley, 1991). Previous studies have also demonstrated that crowding is a risk factor to gingivitis independent of the amount of plaque (Ashley et al, 1998) and only in mouth breathers (Jacobson and Linder-Aronson, 1972), providing another explanation for the higher GI at the anterior region, where dental crowding is more severe. Therefore, there is possibly a combination of factors, namely mouth breathing and dental crowding, accounting for the higher GI at the anterior region. There was no statistically significant relationship between GI and PHP, which may have been influenced by the small sample size.

The results of the present study shed some light on the oral health status of patients with syndromic craniosynostosis. However, due to the small sample size, the statistical information should be carefully considered and further studies on larger samples are warranted to confirm these findings.

Despite the acceptable gingival index, the high plaque index combined with the poor efficacy of toothbrushing and high frequency of restorative needs, indicate the need for the regular dental follow-up of these patients. Notwithstanding the remarkable advances in the rehabilitation of patients with craniofacial anomalies during recent years, their physical aspect is still a stigma, which, associated with the lack of information on this syndrome for undergraduate and graduate students of health sciences and the scarce literature, leads many professionals to fear or refuse to assist these patients. The old belief associating the 'socially unacceptable' physical

aspect with mental delay still persists (Turvey et al, 1979).

Considering this lack of access to dental care, combined with the complications of dental treatment inherent to the syndrome, there is an urgent need to establish a programme for dental follow-up in specialised craniofacial centres, so that they may have access to oral health promotion adequate to their needs and, if possible, to their expectations. Also, parents should receive information on oral health promotion, with emphasis on dietary control and particular risk factors, and should also be encouraged to take responsibility for their children's oral hygiene control.

REFERENCES

1. Ashley FP, Usiskin LA, Wilson RF, Wagaiyu E. The relationship between irregularity of the incisor teeth, plaque, and gingitivis: a study in a group of schoolchildren aged 11–14 years. Eur J Orthod 1998;20:65-72.
2. Carinci P, Becchetti E, Bodo M. Role of the extracellular matrix and growth factors in skull morphogenesis and in the pathogenesis of craniosynostosis. Int J Dev Biol 2000; 44:715-723.
3. Cranioestenose. In: Neuro PUC-PR [online] 2002. http://www.neuropucpr.com.br/manuais/cranioestenose.shtml
4. Ferraro NF. Dental, orthodontic and oral/maxillofacial evaluation and treatment in Apert syndrome. Clin Plast Surg 1991;18:291-307.
5. Gorlin RJ, Cohen Junior MM, Levin LS. Syndromes with craniosynostosis: general aspects and well-known syndromes. In: Syndromes of the Head and Neck. 3rd ed. New York: Oxford University Press 1990;519-536.
6. Jacobson L, Linder-Aronson S. Crowding and gingivitis: a comparison between mouthbreathers and nosebreathers. Scand J Dent Res 1972;80:500-504.
7. Jacobson L. Mouthbreathing and gingivitis. 1. Gingival conditions in children with epipharyngeal adenoids. J Periodontal Res 1973;8:269-277.
8. Kaloust S, Ishii K, Vargervik K. Dental development in Apert syndrome. Cleft Palate Craniofac J 1997;34:117-121.
9. Kreiborg S, Cohen Junior MM. The oral manifestations of Apert syndrome. J Craniofac Genet Dev Biol 1992;12:41-48.
10. Lemmonier J, Hay E, Delannoy P, Fromigué O, Lomri A, Modrowski D, Marie PJ. Increased osteoblast apoptosis in Apert craniosynostosis: role of protein kinase C and interleukin-1. Am J Pathol 2001;158:1833-1842.
11. Löe H. The gingival index, the plaque index and the retention index systems. J Periodontol 1967;38:Suppl:610-616.
12. Mustafa D, Lucas VS, Junod P, Evans R, Mason C, Roberts GJ. The dental health and caries-related microflora in children with craniosynostosis. Cleft Palate Craniofac J 2001;38:629-635.
13. O'Donnell D. Dental management problems related to self-image in Crouzon's syndrome. Aust Dent J 1985;30:355-357.
14. Paravatty RP, Ahsan A, Sebastian BT, Pai KM, Dayal PK. Apert syndrome: a case report with discussion of craniofacial features. Quintessence Int 1999;30:423-426.
15. Podshadley AG, Haley JV. A method for evaluating oral hygiene performance. Public Health Rep 1968;83:259-264.
16. Rynearson RD. Case report: orthodontic and dentofacial orthopedic considerations in Apert's syndrome. Angle Orthod 2000;70:247-252.
17. Salinas CF. Orodental findings and genetic disorders. Birth Defects Orig Artic Ser 1982;18:79-120.
18. Schudy FF. Treatment of Cruson's and Apert's syndromes. J Clin Orthod 1986;20:114-117.
19. Solomon LM, Medenica M, Pruzansky S, Kreiborg S. Apert syndrome and palatal mucopolysaccharides. Teratology 1973;8:287-291.
20. Sonnenberg EM, Catalanotto FA, Nanda R. Apert's syndrome: report of case. ASDC J Dent Child 1977;44:127-130.
21. Turvey TA, Long Junior RE, Hall DJ. Multidisciplinary management of Crouzon syndrome. J Am Dent Assoc 1979;99:205-209.
22. Wagaiyu EG, Ashley FP. Mouthbreathing, lip seal and upper lip coverage and their relationship with gingival inflammation in 11-14 year-old schoolchildren. J Clin Periodontol 1991;18:698-702.
23. World Health Organization. Oral Health Surveys: Basic Methods (4th edition). Geneva: World Health Organization 1997.
24. Zanini SA. Apert, Crouzon, Pfeiffer. In: Cirurgia Craniofacial: Malformações. Rio de Janeiro: Revinter 2000;269-276.