

# Dental arch dimensional changes after adenotonsillectomy in prepubertal children

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**Introduction:** The purposes of this study were to investigate the dental arch changes after adenotonsillectomies in prepubertal children and to compare the dental arch dimensions of mouth-breathing and nasal-breathing children. **Methods:** The sample included 49 prepubertal severely obstructed mouth-breathing children and 46 prepubertal nasal-breathing children. Twenty-four of the 49 mouth-breathing children had an adenotonsillectomy and composed the adenotonsillectomy subgroup. The 25 children in whom the mouth-breathing pattern was unchanged during the 1-year study period composed the control subgroup. **Results:** The mouth-breathing children showed a deeper palatal vault, a larger mandibular width, and a larger mandibular arch length in comparison with the nasal-breathing children. After airway clearance, the adenotonsillectomy group showed a significant maxillary transverse width gain compared with the control subgroup. The control subgroup showed a significant deepening of the palatal height when compared with the adenotonsillectomy subgroup after 1 year. **Conclusions:** The adenotonsillectomy subgroup had a significantly different pattern of arch development compared with the untreated controls. After adenotonsillectomy, the mouth-breathing children showed greater maxillary transverse development than did the controls. The palatal vault deepened in the untreated children. The mouth-breathing children showed a deeper palatal vault, a larger mandibular width, and a larger mandibular arch length in comparison with the nasal-breathing children. (Am J Orthod Dentofacial Orthop 2014;145:461-8)

The association between mouth breathing (MB) and facial morphology impairment is quite old.<sup>1-3</sup> In past years, obstructive sleep apnea, the most extreme type of MB, has received significant attention by orthodontists; this has increased interest in this topic.<sup>4</sup> Previous animal<sup>5,6</sup> and clinical<sup>7-11</sup> studies have provided evidence of the role of MB in abnormal dentofacial growth. The data showed that adaptive changes occur in the form and the size of the maxillary and mandibular dental arches in response to alterations in head, mandibular, and tongue positions. Alterations in the dental arch dimensions such as change in the depth of the palatal vault,<sup>3,8,9,12</sup> decreased intercanine

and molar distances,<sup>9,12</sup> and changes in the position of the incisors are expected to follow changes in the mode of respiration from nasal to oral.<sup>7,13,14</sup> Although such an assumption has a strong theoretical basis in physiopathology, some controversy remains, including whether MB is associated with dental arch deformities,<sup>15,16</sup> and the effect of surgical normalization on breathing mode and dental arch development.

The literature suggests that normalization of the mode of respiration in children results in dentofacial growth similar to that of the nasal-breathing (NB) controls.<sup>7,8,10</sup> It is well accepted that early removal of obstructive tissues in the upper airway during the prepubertal stage of development promotes a positive change in balanced facial growth.<sup>9,10,17</sup> Cohort studies have found no differences in the dental arch morphology of young children treated with tonsillectomy and adenoidectomy, suggesting that the relationship between MB and dental arch dimensional changes is not easily predictable.<sup>9,17,18</sup> Those studies had an NB control group<sup>9,17</sup> or a small sample for the MB control group.<sup>9,18</sup> A longitudinal study with an untreated MB control group would facilitate an understanding of the influence of MB and tonsillectomy and adenoidectomy on the dental arches in prepubertal children.

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All authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest, and none were reported.

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Submitted, March 2013; revised and accepted, December 2013.

0889-5406/\$36.00

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<http://dx.doi.org/10.1016/j.ajodo.2013.12.018>

Since occlusal traits are associated with the mode of breathing, the purpose of this 1-year cohort study was to test, during the prepubertal stage, the null hypotheses that (1) the dental arch dimensional changes after tonsillectomy and adenoidectomy are similar to those observed in the untreated MB control subgroup and (2) there is no difference in the dental arch dimensions of MB and NB children.

## MATERIAL AND METHODS

The study protocol was approved by the ethics committee of the Pontifical Catholic University of Minas Gerais, Belo Horizonte, Brazil. Informed written consent was obtained from the parents before the subjects entered the study.

The sample involved dental casts of 95 prepubertal children (49 MB, 46 NB). All 95 children were in the late deciduous or early mixed dentition at baseline (T0). The median ages at T0 were 6.0 years (mean,  $6.2 \pm 1.7$  years) in the MB group (65.3% boys) and 5.9 years (mean,  $5.9 \pm 1.3$  years) in the NB group (45.6% boys). The ages ranged from 3.11 to 10.10 years at T0. The exclusion criteria were as follows: no history of previous orthodontic or orthopedic treatments, no lip or palate clefts, and no history of a persistent sucking habit at the beginning of the study.

The 49 MB children were selected from a larger project, which was undertaken to investigate the influence of MB on dentofacial growth. These children were consecutively referred by pediatricians or primary care physicians to the Outpatient Clinic for Mouth Breathers at the Federal University of Minas Gerais in Brazil, with the chief complaint of MB. They were systematically evaluated at 1 visit by a multidisciplinary team comprising otorhinolaryngologists, allergists, and orthodontists. Based on the clinical and endoscopic otorhinolaryngology examination performed at the first consultation by 2 authors (L.P.F. and H.M.G.B.), the upper airways were thoroughly examined, and the nasopharyngeal obstructions by adenoidal tissue were classified into the following 3 categories: mild (<50%), moderate (50%-75%), and severe ( $\geq 75\%$ ). Palatine tonsil hypertrophy was classified according to previously published criteria.<sup>19</sup> Children with severe obstructions (nasopharynx obstruction  $\geq 75\%$ <sup>20</sup> or tonsils with grades 3 and 4 according to Brodsky and Koch<sup>19</sup>) with an otorhinolaryngology surgery indication were included in this investigation. Of the 49 MB children, 30 had normal occlusion (Class I deciduous canine relationship, minimal overbite and overjet), and 19 subjects had a Class II relationship. Posterior crossbite was found in 14 MB children, and anterior open bite was diagnosed in 17 impaired subjects. The mean ANB angle was  $5.5^\circ \pm 2.2^\circ$ , and the mean SNB angle was  $75.4^\circ \pm 3.6^\circ$ .

Twenty-four subjects from the 49 in the MB group, who had tonsillectomy and adenoidectomy, were followed for 1 year and comprised the tonsillectomy and adenoidectomy subgroup. The 25 MB children who did not have surgery during the 1-year observation period comprised the untreated control subgroup. No differences were found in the frequency of posterior crossbites or anterior open bites between the tonsillectomy and adenoidectomy and control subgroups. Those children were on the waiting list for authorization for tonsillectomy and adenoidectomy from the municipal health service, which, at the time of the sample collection (2006–2010), generally took more than 1 year for surgical approval because of high demand and low availability. During this waiting period, no children had any medical management (surgical or nonsurgical) that might have altered the soft-tissue inflammation of the airways. [Figure 1](#) is a flowchart of the sampling process.

The NB children were selected from a growth study sample at the Pontifical Catholic University of Minas Gerais (ethics committee CAAE 2001/02) and had normal occlusion (Class I deciduous canine relationship, minimal overbite and overjet). The mean ANB angle was  $5.2^\circ \pm 1.7^\circ$ , and the mean SNB angle was  $76.3^\circ \pm 4.2^\circ$ . A parent of each child was questioned about the child's medical history to exclude any subject with chronic MB, permanent snoring, and tonsillectomy or adenoidectomy. Nasal breathers with obvious hyperplasia of the tonsils and adenoids on the cephalometric images were excluded from further analysis.

The patients in each group were matched by chronological age and stage of skeletal maturation, which was evaluated by the lateral cephalometric radiograph morphologic aspect of the cervical vertebrae C2, C3, and C4.<sup>21</sup> All subjects were in cervical vertebrae stage 1 (prepubertal) at T0, were of the same ethnicity, and lived in the same metropolitan area at the time of the sampling process.

Study casts were taken from all 95 children at T0 and from the tonsillectomy and adenoidectomy and control children at the follow-up, 1 year  $\pm$  2 months later (T1). Their ages ranged from 5.1 to 12 years at T1. Nine dental arch dimension measurements were recorded by 1 examiner (A.C.P.C.) and are illustrated in [Figure 2](#), including the following: maxillary and mandibular intercanine widths, intermolar width, dental arch length, dental arch perimeter, and palatal depth.

To reduce the effect of accidental errors and improve reliability, the mean of 3 consecutive measurements, which were accepted only if they differed by less than 0.5 mm, was used for the calculations. The correlation coefficient (*r*) between the 3 measurements was greater than 0.96 for all variables.

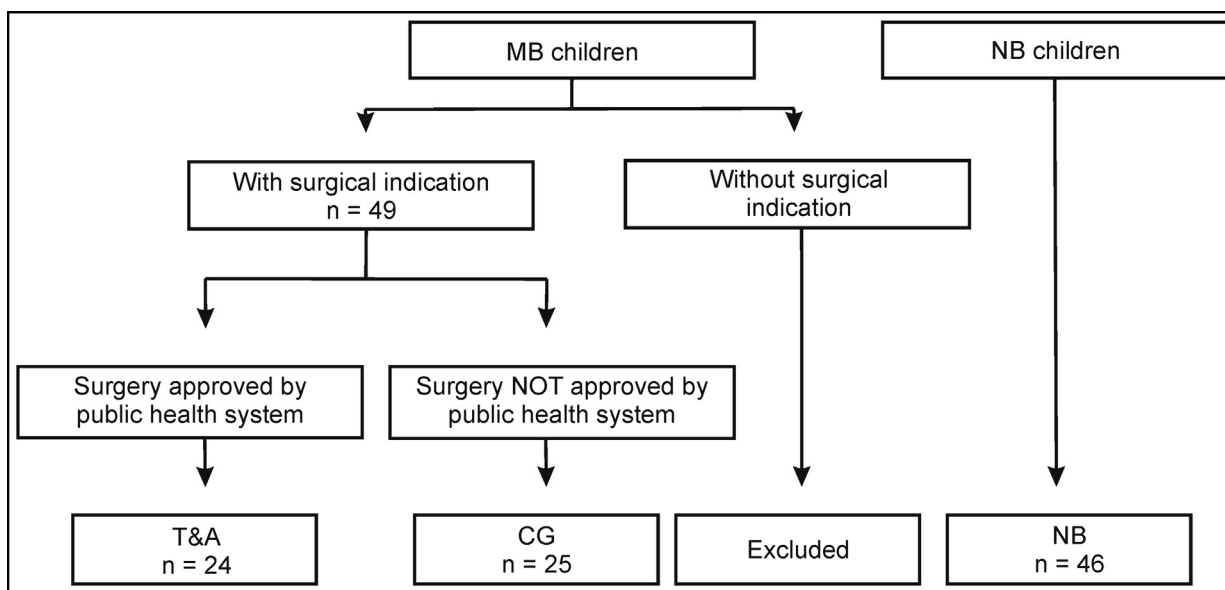


Fig 1. Flowchart of the sampling process.

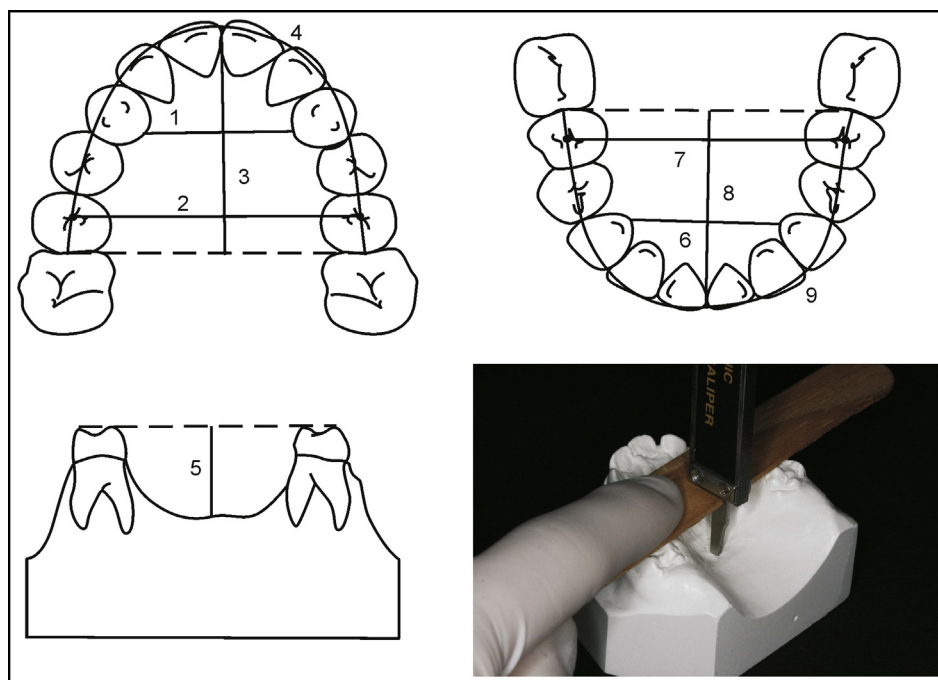


Fig 2. Dental arch measurements. Maxillary arch: 1, intercanine and 2, intersecond molar widths; 3, arch length; 4, arch perimeter; 5, palatal depth. Mandibular arch: 6, intercanine and 7, intersecond molar widths; 8, arch length; 9, arch perimeter. The photo show the measurement of palatal depth.

The definition of each measurement is as follows.

1. Maxillary and mandibular intercanine width: the distance (mm) between the most cervical lingual portion of the maxillary and mandibular right and

left deciduous canine. The landmarks were placed at the gingival margin of the teeth on the assumption that the measurement is not affected by attrition or malposition of the teeth.

2. Maxillary and mandibular intermolar width: the distance (mm) between the central fossae of the right and left deciduous second molars in both arches.
3. Maxillary and mandibular dental arch length: the distance (mm) between the central incisors' mid-points and the tangent line to the distal surface of the right and left deciduous second molars in both arches. The dental arch length denotes the sagittal dimension from the most anterior reference point to the posterior surface.
4. Maxillary and mandibular dental arch perimeters: the contour of the dental arch (mm) measured from the distal surface of the left deciduous second molar to the distal surface of the right deciduous second molar passing over the central fossae of the deciduous molars, the tip of the deciduous canine, and the incisal edge of the incisors. The dental arch perimeter denotes the shape of the dental arch.
5. Palatal depth: measured from the deepest point in the palate to a line connecting the mesiolingual tips of the deciduous second molars cusps. To record this, the tip of a digital caliper was inserted into the curved groove of a 1.74-mm-thick wooden tongue depressor, as shown in Figure 2.

A digital caliper (4 in, model 47256; Cen-Tech, Pittsburgh, Pa), accurate to 0.001 mm, was used in the measurements. The evaluations were performed at T0 and repeated at T1. Measurements associated with exfoliated teeth were considered missing values for the subject.

To determine errors in the dental arch measurements, 52 randomly selected dental casts were remeasured by the same examiner at least 1 month later. The random errors were calculated using Dahlberg's formula,<sup>22</sup> and the systematic errors (bias) were assessed using the paired *t* test at  $P < 0.05$ .

### Statistical analysis

The data were analyzed using SPSS software (version 12.0; SPSS, Chicago, Ill). The systematic errors in the measurements did not exceed 0.02 mm and were thus considered to be of no further importance. The random errors ranged between 0.03 and 0.05 mm for the linear measurements. There were no statistically significant differences among the 3 measurements. The significance level was set at 5%. The Kolmogorov-Smirnov and Levene tests demonstrated normality and homoscedasticity, respectively, and thus the independent-sample *t* test was used.

### RESULTS

Four of the 9 measurements (Fig 2) at T0 showed differences between the MB and NB groups. Statistically

**Table I.** Dental arch measurements at T0

| Measurement (mm)                 | MB<br>(n = 49) |      | NB<br>(n = 46) |      | Independent<br>t test |
|----------------------------------|----------------|------|----------------|------|-----------------------|
|                                  | Mean           | SD   | Mean           | SD   | P value               |
| Maxillary intercanine width      | 22.78          | 2.41 | 22.93          | 1.49 | 0.711                 |
| Maxillary second molar width     | 39.31          | 2.17 | 39.11          | 1.83 | 0.630                 |
| Maxillary dental arch length     | 26.18          | 2.17 | 26.38          | 1.58 | 0.616                 |
| Maxillary dental arch perimeter  | 75.69          | 5.70 | 75.46          | 3.48 | 0.813                 |
| Palatal depth                    | 14.60          | 1.51 | 13.87          | 1.22 | 0.013*                |
| Mandibular intercanine width     | 18.45          | 1.84 | 17.62          | 1.38 | 0.016*                |
| Mandibular second molar width    | 35.61          | 1.96 | 34.32          | 1.81 | 0.001*                |
| Mandibular dental arch length    | 22.28          | 1.64 | 23.38          | 1.30 | 0.001*                |
| Mandibular dental arch perimeter | 68.14          | 3.69 | 68.14          | 3.27 | 0.999                 |

All means showed equal variance and normal distribution.  
\* $P < 0.05$ , indicates statistical significance.

**Table II.** Dental arch measurements of the adenotonsillectomy (T & A) and control (CG) subgroups

| Measurement (mm)                 | T & A<br>(n = 24) |      | CG<br>(n = 25) |      | Independent<br>t test |
|----------------------------------|-------------------|------|----------------|------|-----------------------|
|                                  | Mean              | SD   | Mean           | SD   | P value               |
| Maxillary intercanine width      | 22.71             | 2.32 | 22.84          | 2.54 | 0.847                 |
| Maxillary second molar width     | 38.93             | 2.02 | 39.67          | 2.29 | 0.240                 |
| Maxillary dental arch length     | 25.89             | 2.18 | 26.46          | 2.26 | 0.367                 |
| Maxillary dental arch perimeter  | 75.34             | 5.37 | 76.03          | 6.09 | 0.675                 |
| Palatal depth                    | 14.40             | 1.41 | 14.81          | 1.62 | 0.368                 |
| Mandibular intercanine width     | 18.88             | 1.46 | 17.99          | 2.10 | 0.098                 |
| Mandibular second molar width    | 35.96             | 1.74 | 35.27          | 2.14 | 0.222                 |
| Mandibular dental arch length    | 22.13             | 1.60 | 22.41          | 1.70 | 0.552                 |
| Mandibular dental arch perimeter | 67.82             | 3.44 | 68.45          | 3.97 | 0.562                 |

All means showed equal variance and normal distribution.

significant differences ( $P < 0.05$ ) were observed between the MB and NB groups regarding palatal depth (MB, 14.60 mm vs NB, 13.87 mm), mandibular intercanine width (MB, 18.45 mm vs NB, 17.62 mm), mandibular second molar width (MB, 35.61 mm vs NB, 34.32 mm), and mandibular dental arch length (MB, 22.28 mm vs NB, 23.38 mm) (Table I). When the MB group was stratified into 2 groups, no statistically significant differences were found between the tonsillectomy and adenoidectomy and the control subgroups at T0 (Table II). Table III presents the dental arch measurements of the

**Table III.** Dental arch measurements of the adenotonsillectomy (T & A) and control (CG) subgroups

| Measurement (mm)                 | T & A<br>(n = 24) |       | T & A paired t test<br>(T1-T0) | CG<br>(n = 25) |       | CG paired t test<br>(T1-T0) | Independent t test at T1<br>(T & A vs CG) |
|----------------------------------|-------------------|-------|--------------------------------|----------------|-------|-----------------------------|---|
|                                  | T0                | T1    | P value                        | T0             | T1    | P value                     | P value                                   |
| Maxillary intercanine width      | 22.24             | 23.23 | 0.004*                         | 22.67          | 23.19 | 0.003*                      | 0.952                                     |
| Maxillary second molar width     | 38.94             | 39.34 | 0.023*                         | 39.67          | 39.78 | 0.153                       | 0.512                                     |
| Maxillary dental arch length     | 25.89             | 26.06 | 0.864                          | 26.46          | 26.87 | 0.016*                      | 0.225                                     |
| Maxillary dental arch perimeter  | 75.34             | 76.38 | 0.137                          | 76.26          | 77.82 | 0.003*                      | 0.386                                     |
| Palatal depth                    | 14.40             | 14.50 | 0.648                          | 14.81          | 15.18 | 0.024*                      | 0.122                                     |
| Mandibular intercanine width     | 18.92             | 19.40 | 0.031*                         | 17.99          | 18.63 | 0.002*                      | 0.284                                     |
| Mandibular second molar width    | 35.91             | 35.98 | 0.581                          | 35.22          | 35.49 | 0.019*                      | 0.441                                     |
| Mandibular dental arch length    | 22.13             | 22.04 | 0.475                          | 22.41          | 22.68 | 0.317                       | 0.133                                     |
| Mandibular dental arch perimeter | 67.82             | 68.24 | 0.171                          | 68.45          | 69.27 | 0.004*                      | 0.375                                     |

All means showed equal variance and normal distribution.

\*P < 0.05, indicates statistical significance.

tonsillectomy and adenoidectomy and control subgroups. Paired *t* tests compared T0 and T1 in the tonsillectomy and adenoidectomy and control subgroups; independent *t* tests compared the tonsillectomy and adenoidectomy and control subgroups at T1. In the untreated children, 7 of 9 measurements had statically significant differences between T0 and T1. On the other hand, the tonsillectomy and adenoidectomy children showed differences from T0 to T1 in only 3 measurements. The dimensional changes in the dental arches of the tonsillectomy and adenoidectomy and the control subgroups between T0 and T1 were converted into percentages of the changes (Figs 3 and 4) because the head size of children can vary even in the same developmental stage. The major results can be summarized as follows.

The maxillary transverse dimension of the tonsillectomy and adenoidectomy children (intercanine and intersecond molar widths) increased significantly from T0 to T1 in comparison with the control subgroup (*P* < 0.05) (Fig 3, A and B). The maxillary intercanine width increased 5.12% in the tonsillectomy and adenoidectomy subgroup; in the control subgroup, a 2.07% increase was observed. The maxillary arch intermolar width in the tonsillectomy and adenoidectomy subgroup increased by 1.21% in the 1 year after the adenotonsillectomy, and in the control subgroup, a 0.13% increase was measured. The maxillary arch perimeter and arch length gains were similar between the tonsillectomy and adenoidectomy and control subgroups.

Figure 3, E, illustrates that the palatal vault increased significantly from T0 to T1 in the control subgroup (2.57% of change) in comparison with the tonsillectomy and adenoidectomy subgroup (0.09% of change).

The mandibular arch length changes from T0 to T1 did not show statistically significant differences between the tonsillectomy and adenoidectomy and the control

subgroups. The mandibular intercanine (Fig 4, A) and intermolar (Fig 4, B) widths, as well as arch perimeters (Fig 4, D), increased during the 1-year observational period in both subgroups, and arch length decreased (Fig 4, C).

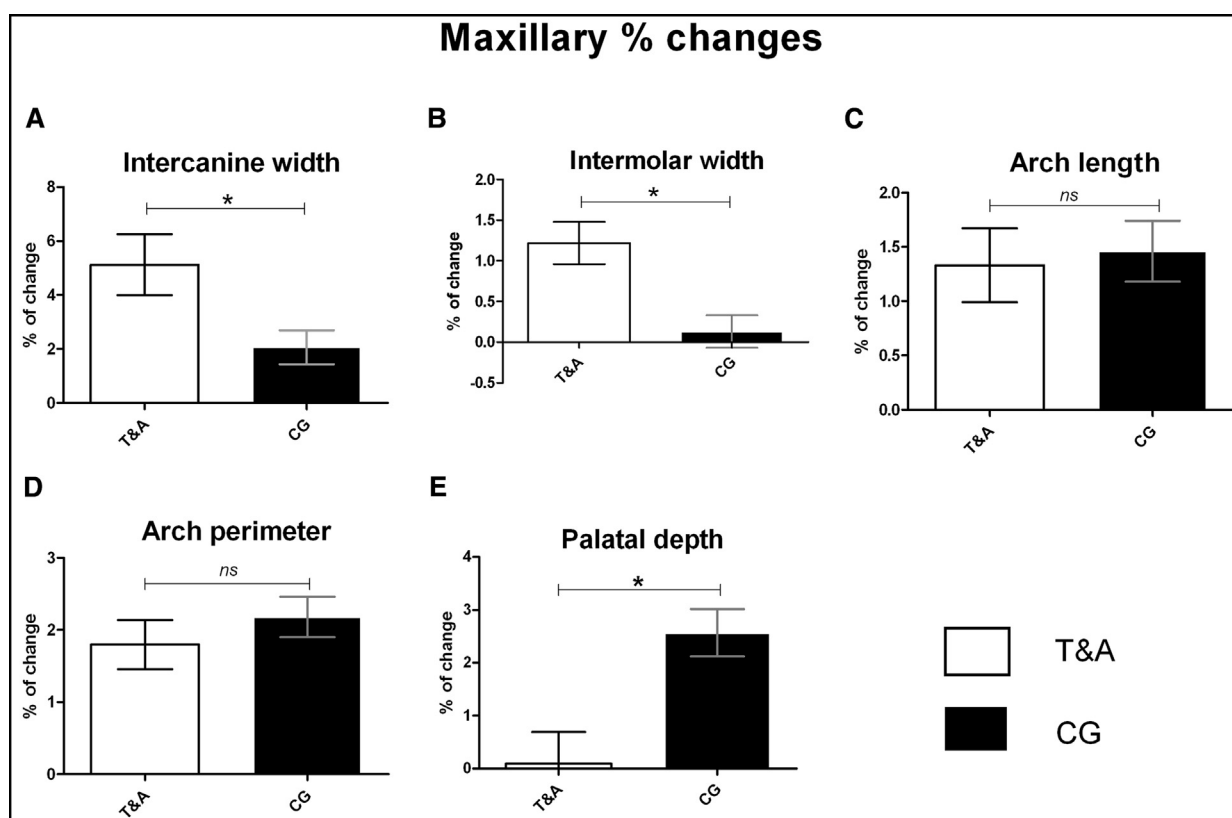
### DISCUSSION

Previous studies have demonstrated that MB children commonly have smaller arch widths and lengths, a greater palatal depth, and a craniofacial growth disharmony.<sup>9,10,16,18,23,24</sup> Our MB group had a shorter mandibular arch length, a deeper palatal vault, and greater mandibular width. During the 1-year follow-up, we studied whether the tonsillectomy and adenoidectomy children have similar dimensional arch changes compared with the untreated controls. The results demonstrated that the untreated patients showed increased palatal depth and less maxillary intercanine and intermolar molar width gains. No association was found between adenotonsillectomy and mandibular changes.

In our severely obstructed MB sample, 75% of the subjects had a palatal depth greater than the mean measurement in the NB group. Previous authors have observed a deep palatal vault in MB children.<sup>8,12,25</sup> The palatal depth increase might be intuitively explained by the decreased growth rate of the transverse dimension of the maxillary arch,<sup>3</sup> as well as by the nasal cavity hypofunctionality.<sup>26</sup> The control group of children whose persistent obstruction was maintained during the 1-year observational period showed less maxillary width gain than those who had surgical normalization of respiration (tonsillectomy and adenoidectomy), as well as greater palatal depth development.

At T0, the mandibular width was enlarged in the MB group in comparison with the NB group. Such mandibular arch expansion might be explained by increased positive tongue pressure on the lingual aspect of the





**Fig 3.** Comparison between the tonsillectomy and adenoidectomy and control groups in regard to the percentages of change in the dimensions of the maxillary dental arch from T0 to T1. *ns*, Not statistically significant.

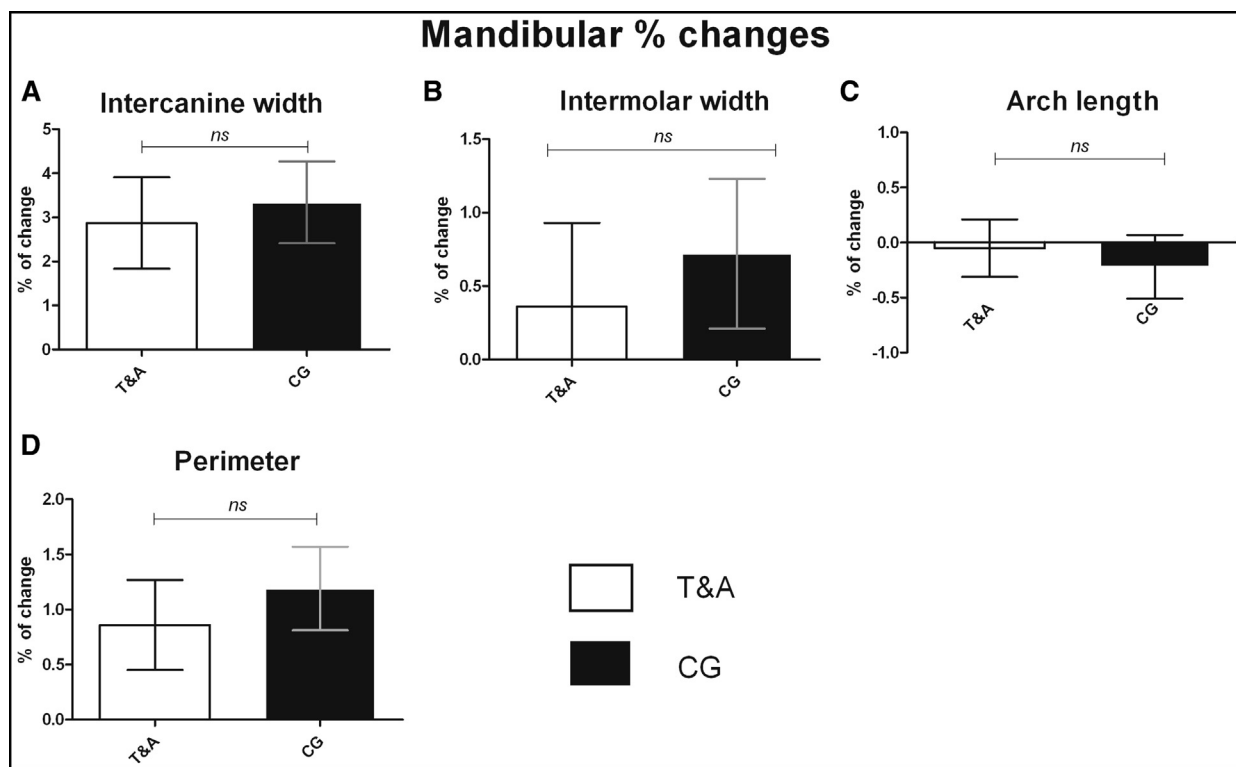
posterior teeth, after its lowered position to allow airflow through the oral cavity, as postulated by some studies.<sup>23</sup> Nongenetic factors explain the majority of the variations in dental arch measurements.<sup>15,18,24</sup>

The maxillary and mandibular perimeters and arch lengths in the MB group were similar to those of the NB group, except that mandibular arch length was shorter. Our data corroborate previous described findings.<sup>18,24</sup> In the MB group, the extension of the head, the tongue passing over the mandibular incisor border, and the increased lower lip pressure on the buccal surfaces of the mandibular incisors might retrocline these teeth, partially explaining the shortening of the arch length.<sup>26</sup> We did not evaluate the incisors' inclinations, and such inferences about arch length are a hypothesis.

In this study, the prevalence of dental Class II malocclusion in the MB children was 38.7%; this agrees with a previous study.<sup>11</sup> However, no difference was found in the sagittal skeletal relationships (ANB and SNB angles) between the MB and NB children. Although some investigations have pointed out that posterior transverse

interarch discrepancies might be associated with Class II malocclusion,<sup>27</sup> this issue is still controversial during childhood and adolescence.<sup>28</sup> We believe that a deeper palatal vault and a greater mandibular width in MB children might be partially associated with the higher prevalence of Class II malocclusion in this group, despite the skeletal similarities between the groups. However, it is not possible to infer with this study design the cause-and-effect relationship between transverse and sagittal discrepancies in the MB group. Moreover, the sagittal dental and skeletal patterns had no influence on the dimensional arch changes after adenotonsillectomy, since the tonsillectomy and adenoidectomy and control subgroups had the same skeletal and dental patterns.

Our findings are contrary to those of a recent study that did not find differences in the pattern of maxillary transverse growth after surgery.<sup>17</sup> In our sample, at 1 year after the tonsillectomy and adenoidectomy, the deciduous second molar width increase was 1.21%, contrasting with 0.13% in the control subgroup. A previous study found an increased transverse distance between the maxillary molars 1 year after the adenotonsillectomy.<sup>13</sup> The maxillary



**Fig 4.** Comparison between the tonsillectomy and adenoidectomy and control groups in regard to the percentages of change in the dimensions of the mandibular dental arch from T0 to T1. *ns*, Not statistically significant.

intercanine width gain in the tonsillectomy and adenoidectomy subgroup was a change of 5.12%; in the control subgroup, a change of 2.07% was measured. Despite the statistically significant difference, the linear changes seemed quite small (Table III); thus, clinical significance might be questioned. However, they showed a clinical trend in time when the impaired breathing pattern was maintained. If a 0.5-mm arch change occurred in the 1-year observation period, what would happen if 5 years of untreated MB is left? The 1-year follow-up might not be enough time for conclusions, and a long-term investigation is needed. It is clear that the airway obstruction relief in children had some influence in the arch development during the first year after the change from MB to NB. Such transverse growth is similar to that described previously in which 0.6 mm was found 1 year postoperatively.<sup>10</sup> Despite this diminished maxillary arch transverse growth trend in the obstructed children, the maxillary widths of the MB and NB children remained similar at T1.

In the control subgroup, after 1 year of uncontrolled severe MB, the palatal depth increased significantly; in the tonsillectomy and adenoidectomy children, the palatal vault was fairly stable. It suggests that with

MB, the tendency of the palatal roof is to deepen, whereas a more normal growth pattern is established after tonsillectomy and adenoidectomy.

It was possible to use the control subgroup without ethical concerns because of the public health system in our municipality. The unbalanced ratio between the demand for and the availability of tonsillectomy and adenoidectomy surgical procedures from 2006 to 2010 imposed a waiting period of a number of months for children with an adenotonsillectomy indication to obtain official authorization for the procedure. Because those children, while waiting for the surgery, returned regularly for clinical otorhinolaryngology checkups, but with no medication prescribed to control the soft-tissue inflammation of the airway, they could systematically receive a new orthodontic examination. This sample in which arch development was documented with a severe airway obstruction is novel in the scientific literature. Such data can contribute to the understanding of the etiologic participation of severe airway obstruction on the developmental changes of the dental arches in children.

Our findings suggested that adenotonsillectomy could contribute to the morphologic development of

such structures. Orthodontists should be alert to dental arch dimensional changes in prepubertal MB children. When signs of transverse dental arch impairment are diagnosed, referral to an otorhinolaryngologist to evaluate the indication for surgical normalization of the breathing pattern can benefit the discussion of the consequences of the intra-arch dimensions.

## CONCLUSIONS

The null hypothesis was rejected. The tonsillectomy and adenoidectomy subgroup had a significantly different pattern of arch development compared with the untreated control subgroup. After adenotonsillectomy, the MB children showed greater maxillary intercanine and intermolar development than did the untreated controls. The palatal vault deepened in the untreated children. The MB group showed deeper palatal vaults, greater mandibular intercanine and intermolar widths, and greater mandibular arch lengths in comparison with the NB children at T0.

## ACKNOWLEDGMENTS

We thank Luana Araujo Ferro Fialho for her time and dedication to this study. Her effort was crucial for its completion.

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