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Do gender and age influence hard palate dimensions? A systematic review

O gênero e a idade influenciam as dimensões do palato duro? Revisão sistemática da literatura

ABSTRACT

Purpose: Analyze the influence of gender and age on hard palate dimensions and verify the reference parameters available in the literature. **Research strategies:** Two reviewers independently performed a search at the Cochrane Library, PubMed-Medline and Web of Knowledge databases using descriptors according to the syntax rules of each database. **Selection criteria:** Observational or experimental human studies evaluating the dimensions of the hard palate or maxillary dental arch, with at least one transverse, vertical or sagittal plane measurement, in normal occlusions or class I malocclusions, and comparisons of the dimensions between genders and/or ages. **Data analysis:** Descriptive analysis with the following subdivisions: design, sample, evaluation instruments, measurements in millimeters, and statistical analysis. Quality of the included studies was verified by the Newcastle - Ottawa Quality scale. **Results:** Eighteen studies were selected and 11 presented results for hard palate or maxillary dental arch dimensions according to gender, six in age and gender and one in age only. **Conclusion:** The dimensions were larger in males and progressive increase in the measurements was observed from birth to the permanent dentition period.

RESUMO

Objetivo: Analisar a influência do gênero e da idade nas dimensões do palato duro, bem como verificar os parâmetros de referência disponíveis na literatura. **Estratégia de pesquisa:** Dois examinadores realizaram a pesquisa de forma independente nas bases de dados Cochrane Library, PubMed-Medline e Web of Knowledge utilizando os descritores de acordo com as regras de sintaxe de cada banco de dados. **Critérios de seleção:** Estudos em humanos observacionais ou experimentais, que avaliaram as dimensões do palato duro ou do arco dentário maxilar com pelo menos uma mensuração no plano transversal, vertical ou sagital em oclusões normais ou más oclusões classe I e que realizaram comparações das dimensões entre os gêneros e/ou idades. **Análise de dados:** Análise descritiva, seguindo subdivisões: delineamento, amostra, instrumentos de avaliação, medidas em milímetros e análise estatística. A qualidade dos estudos incluídos foi verificada através da escala "Newcastle - Ottawa Quality". **Resultados:** Foram selecionados 18 estudos. Destes, 11 apresentaram resultados das dimensões do palato duro ou do arco dentário maxilar conforme o gênero, seis em idade e gênero e um somente em idade. **Conclusão:** As medidas foram maiores no gênero masculino e houve um aumento progressivo nas dimensões do nascimento até o período de dentição permanente.

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INTRODUCTION

Orofacial myofunctional evaluation includes a visual and subjective inspection of the hard palate through anthroposcopic assessment. Current clinical assessment protocols include evaluation of width and depth of the hard palate^(1,2), because the morphology of the structures of the stomatognathic system are crucial for the correct processing functions of this system⁽³⁾.

Although anthroposcopic assessment of the hard palate is the most frequently used method among pathologists, it has limitations because of the lack of clinical parameters to classify width and depth of the hard palate as normal, reduced or increased.

Current research on orofacial myology is aimed at studying quantitative methods of evaluation that can complement orofacial myofunctional clinical examination. In the literature, there are some resources for quantitative assessment of the hard palate in research whose objective is to compare the dimensions of the hard palate between different clinical groups⁽⁴⁻⁸⁾ or compare qualitative and quantitative evaluations of the hard palate^(3,9). However, in order to make the use of such resources feasible in clinical practice, knowledge is required of reference parameters for quantitative analysis of the hard palate according to gender and age.

Therefore, this systematic review of the literature is relevant because it seeks to answer the following research questions: Do age and gender influence hard palate dimensions? What are the reference parameters of hard palate dimensions?

The objective of this study was to conduct a systematic review of the literature to evaluate the influence of gender and age on hard palate dimensions as well as check the reference parameters available in the literature.

Research strategy

The aim of this systematic review of the literature was to assess the association between gender and age and hard palate dimensions. This is not a systematic review of intervention as described in *the Cochrane Handbook and the PRISMA statement*. However, the PRISMA guidelines were followed whenever possible.

Two examiners with knowledge in the field conducted the research independently (LCB AND MM). They searched for

articles published until June 2017 in the Cochrane Library, PubMed-Medline and Web of Knowledge.

Only articles published in English were considered. Appropriate adjustments were made to the keywords to follow the syntax rules of each database (Table 1).

The two examiners evaluated the titles and abstracts of all studies they had found. Abstracts with sufficient information to allow inclusion or exclusion decisions were analyzed in full prior to the final decision. Articles that had appeared in different databases were considered only once. Different decisions by the two researchers were resolved by consensus. The selected articles were then carefully analyzed for quality assessment, bias control and data extraction.

The search had to be broadened to include studies that had performed measurements of the maxillary dental arch, as there were few papers that had analyzed the hard palate. This inclusion was made because the hard palate and the maxillary dental arch are closely related, since they are on the same plane of the maxilla and have a similar shape.

Selection criteria

This research included experimental or observational studies conducted with humans which assessed the dimensions of the hard palate or maxillary dental arch with at least a measurement in the transverse, vertical or sagittal plane in normal occlusions or Angle Class I malocclusions and compared such dimensions with gender and/or age.

Studies were excluded when they had samples with craniofacial deformities, cleft palate, syndromes, mouth breathing, crossbite, open bite, and history of orthodontic treatment.

Data analysis

After the selected articles were read in full, the following data were extracted: name of authors, year of publication, country where the study was conducted, study design, objective of the study, characteristics of the sample, instruments used for measuring the hard palate or maxillary dental arch, description of the measures undertaken, average of measures in accordance with gender and/or age and significance value (p-value) when available.

Table 1. Database and search strategies in use

| Database | Descriptors |
|-------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Cochrane Library http://cochrane.bvsalud.org/portal/php/index.php | (palat* or "dental arch") and measure* or height or depth or width or dimension) and (Korkhaus or compass or caliper or cone-beam or cast) and ("age groups" or age or sex or gender dimorphism or not (deformities or airway or cleft or implant). |
| PubMed-Medline http://www.ncbi.nlm.nih.gov/pubmed | (palat* or "dental arch") and measure* or height or depth or width or dimension) and (Korkhaus or compass or caliper or cone-beam or cast) and ("age groups" or age or sex or gender dimorphism or not (deformities or airway or "Cleft Palate or cleft or implant" or "mini" or miniscrew implant or thickness). Filter was checked for studies using HUMANS. |
| Web of Knowledge http://apps.webofknowledge.com | (palat* or "dental arch") and (measure* or height or depth or width or dimension) and (Korkhaus or compass or caliper or cone-beam or cast) and ("age groups" or age or sex or dimorphism or gender) not (deformities or airway or "Cleft Palate" or cleft or implant or "mini implant" or miniscrew or thickness). |

Quality and risk of bias of the included studies were assessed by means of the scale “*Newcastle - Ottawa Quality*”, originally designed for cohort studies⁽¹⁰⁾, and subsequently adapted for cross-sectional studies⁽¹¹⁾. On the scale, the score is given in number of stars comprising three domains: selection, comparability and outcome/result. The maximum score can be nine points for cohort studies and ten points for cross-sectional studies. The higher the score achieved, the greater the internal quality and the lower the risk of bias in the study.

RESULTS

The flowchart shows the results of the searches (Figure 1): 215 studies were found in the database Web of Knowledge, 114 in Pubmed-Medline and 39 in the Cochrane Library. According to the selection criteria, 46 studies were selected in accordance with the title and abstract, five of which were excluded for being duplicated. After the articles were read in full, 28 were excluded because they did not fulfill the selection criteria, while 18 studies were included.

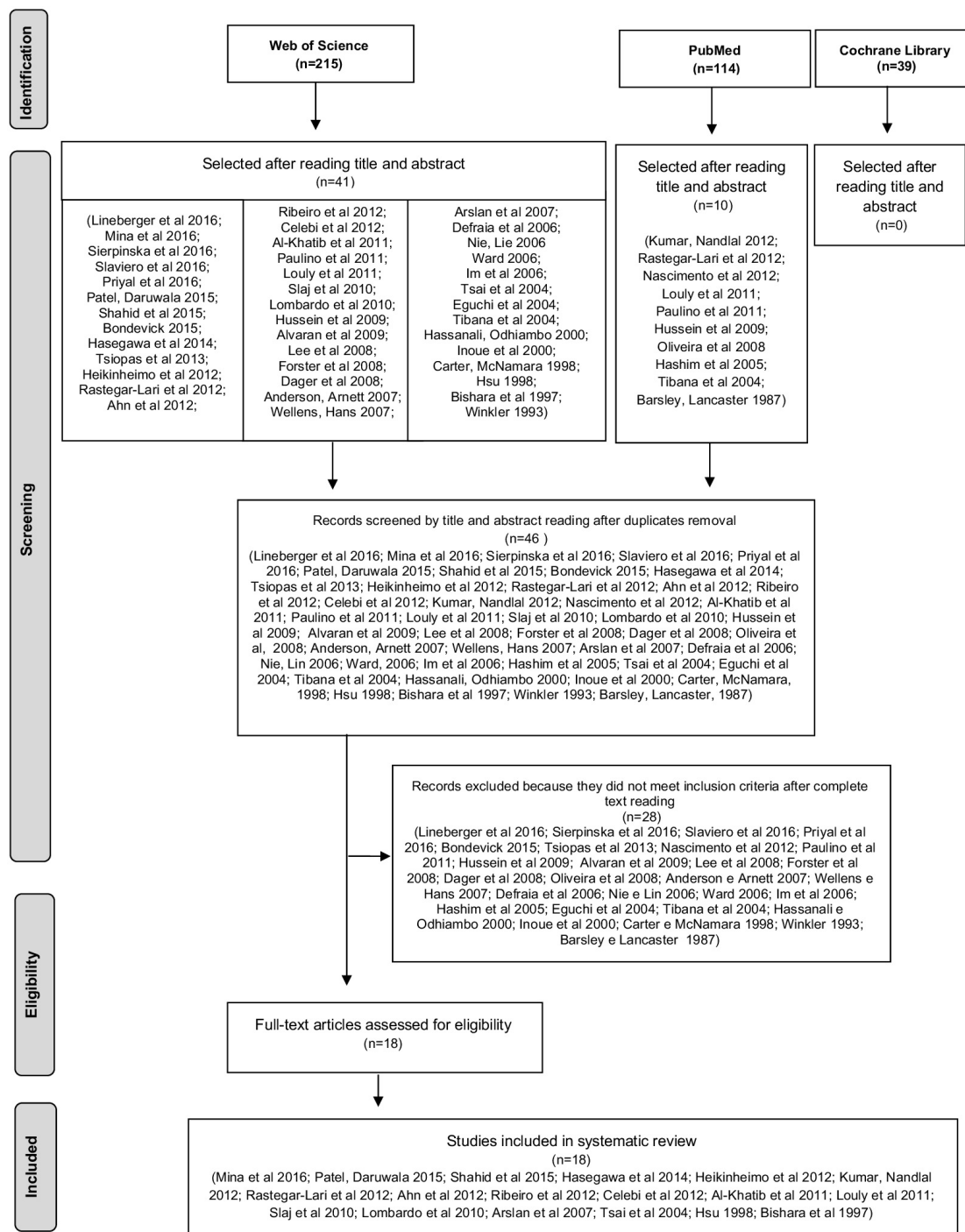


Figure 1. Flow chart of the present research

In the phase of data extraction from the 18 studies included in this systematic review, there was variability in the types of measurements and reference points. Therefore, measurements were made of the vertical transverse, and sagittal planes, which are those of greatest interest to speech-language therapy.

To adequately present a summary of the results of the 18 studies in Table 2, standardization was applied to the names of measures and their appropriate abbreviations with mention to a point of reference in use (Chart 1). When the reference points used for measurement were marked on the gums, they were considered as hard palate dimensions. When the reference points were marked on the teeth (cusps, grooves or pits), they were considered as maxillary dental arch dimensions.

The designations of hard palate measures (Chart 1) were standardized because of the lack of standardization in the use of

nomenclatures for the measurements performed in the 18 studies. It was found that five studies had termed the measures of the sagittal plane of the arch as depth^(12,13,24-26), while the other four had called them length^(15,19,20,23). In four studies, the measure called “depth” was related to the vertical plane^(19,23,27,28). Thus, we chose to standardize the measurements of the sagittal plane as “length” and those of the vertical plane as “depth”. The measures of the transverse plane were called “width” (Chart 1).

All of the included studies performed the measurements based on plaster casts of the maxillary dental arch. The measurements were performed directly on the models with a dial or a digital caliper^(14,15,17-19,20,23,26,29), a dial caliper with a gauge to measure palate height⁽¹⁹⁾ or with a three-dimensional Korkhaus compass⁽²³⁾; in scanned models, in pictures and copiers, they were measured

Table 2. Studies comparing hard palate or maxillary dental arch dimensions between genders and/or ages

| Author, year, country | Sample | Instruments | Measurements in males millimeters (mm) | Measurements in females millimeters (mm) | Statistical analysis |
|---------------------------------------------|--------------------------------------|-----------------------------------------------------------|----------------------------------------------------|----------------------------------------------------|--------------------------------------------------------|
| Mina et al. ⁽¹²⁾ Iran | 54 subjects | Scanned model: - Measures in 3D image with software | 1M.Wi.bg=58.93 | 1M.Wi.bg=57.06 | N.S. Between genders |
| | M=25 F=29 | | | | |
| | 12 to 16 years Mean age: 14 years | | 1M.Le=32.42 | 1M.Le=30.82 | |
| Patel and Daruwala ⁽¹³⁾ India | 60 subjects | - Measures in 3D image with software | C.Wi.cus=34.97 ^a | C.Wi.cus=33.14 ^a | Equal Letters: differences between genders |
| | M=30 F=30 | | 2M.Wi.dbc=58.84 ^b | 2M.Wi.dbc=55.99 ^b | |
| | 18-25 years | | C.Le=8.47 ^c 2M.Le=42.54 ^d | C.Le=7.86 ^c 2M.Le=40.87 ^d | |
| Shahid et al. ⁽¹⁴⁾ Pakistan | 128 subjects | Plaster cast: | Digital caliper: | Digital caliper: | Equal Letters: differences between genders |
| | 18-24 years | - Digital caliper | C.Wi.cus=35.99 ^a | C.Wi.cus=34.24 ^a | |
| | | Scanned model: | 1PM.Wi.bc=43.37 ^b | 1PM.Wi.bc=41.99 ^b | |
| | | - SM technique | 2PM.Wi.bc=48.97 ^c | 2PM.Wi.bc=47.04 ^c | |
| | | | 1M.Wi.mbc=53.97 ^d | 1M.Wi.mbc=52.16 ^d | |
| | | | SM technique: | SM technique: | |
| | | | C.W.cus=35.99 ^e | C.W.cus=34.26 ^e | |
| | | | 1PM.Wi.bc=43.37 ^f | 1PM.Wi.bc=42.00 ^f | |
| Hasegawa et al. ⁽¹⁵⁾ Japan | | | 2PM.Wi.bc=48.97 ^g | 2PM.Wi.bc=47.04 ^g | Equal letters: differences between genders |
| | | | 1M.Wi.mbc=53.97 ^h | 1M.Wi.mbc=52.15 ^h | |
| | 100 subjects from Mongolia: | Plaster cast: | Mongolians: | Mongolians: | |
| | M=50 F=50 | - Digital caliper | C.Wi.g=26.37 ^a | C.Wi.g= 25.37 ^a | |
| | Mean age: | | 1PM.Wi.g=30.97 ^b | 1PM.Wi.g=29.55 ^b | |
| | 20.8 years | | 1M.Wi.g=40.69 ^c | 1M.Wi.g=38.32 ^c | |
| | 100 subjects from Japan | | 1M.Wi.cf=51.58 ^d | 1M.Wi.cf=49.11 ^d | |
| | M=50 F=50 | | 1M.Le= 32.32 | 1M.Le= 31.93 | |
| | Mean age: | | 1M.LeB=32.80 ^e | 1M.LeB=34.73 ^e | |
| | 20 years | | 1PM.WiB= 49.35 ^f | 1PM.WiB=47.47 ^f | |
| | | Japanese: | Japanese: | | |
| | | C.Wi.g=26.45 ^g | C.Wi.g= 22.96 ^g | | |
| | | 1PM.Wi.g=30.12 ^h | 1PM.Wi.g=27.38 ^h | | |
| | | 1M.Wi.g=38.68 ⁱ | 1M.Wi.g=35.57 ⁱ | | |
| | | 1M.Wi.cf= 49.85 ^j | 1M.Wi.cf=43.54 ^j | | |
| | | 1M.Le= 33.97 ⁱ | 1M.Le= 30.28 ⁱ | | |
| | | 1PM=30.82 | BL.1PM=31.32 | | |
| | | | 1PM.WiB= 46.52 ^m | 1PM.WiB=40.41 ^m | |

Caption: M=males; F=females; 3D=three-dimensional; 2D=two-dimensional; NS= non-significant

Table 2. Continued...

| Author, year, country | Sample | Instruments | Measurements in males millimeters (mm) | Measurements in females millimeters (mm) | Statistical analysis |
|-----------------------------------------------|-------------------------------------------|-----------------------------------------|-------------------------------------------|---------------------------------------------|--------------------------------------------------------|
| Ahn et al. ⁽¹⁶⁾ South Korea | 66 subjects | Scanned model: | C.Wi.cus: | C.Wi.cus: | Equal letters: differences between genders |
| | M=16 F=50 | - Measures in 3D image with software | 6 years =32.33 | 6 years =32.11 | |
| | 6-14 years | | 8 years =34.33 | 8 years =33.97 | |
| | | | 9 years =32.92 | 9 years =33.69 | |
| | | | 10 years =33.77 | 10 years =35.14 | |
| | | | 11 years =33.53 | | |
| | | | C.Wi.cus: | C.Wi.cus: | |
| | | | | 8 years =34.30 | |
| | | | 9 years =39.58 | 9 years =35.14 | |
| | | | 10 years =38.36 ^a | 10 years =35.78 ^a | |
| | | | 11 years =37.45 | 11 years =35.85 | |
| | | | 12 years =37.30 ^b | 12 years =35.75 ^b | |
| | | | 13 years =37.24 ^c | 13 years =35.70 ^c | |
| | | | 14 years =37.15 ^d | 14 years =35.58 ^d | |
| Celebi et al. ⁽¹⁷⁾ Turkey | 142 subjects: | Plaster cast: | 1PM.Wi.cg=35.95 | 1PM.Wi.cg=35.56 | N.S. Between genders |
| | M=64 F=78 | -Digital caliper | 1M.Wi.cf=46.25 | 1M.Wi.cf=45.18 | |
| | 14-15 years | | | | |
| Heikinheimo et al. ⁽¹⁸⁾ Finland | 33 subjects: | Plaster cast: | C.Wi.cus: | C.Wi.cus: | Descriptive analysis |
| | M=15 F=18 | -Digital caliper | 7 years =32.49 | 7 years =32.51 | |
| | Assessed at 7, 10, 12, 15 and 32 years | | 10 years =33.89 | 10 years =33.52 | |
| | | | 12 years =35.76 | 12 years =33.73 | |
| | | | 15 years =35.85 | 15 years =34.16 | |
| | | | 32 years =35.41 | 32 years =33.88 | |
| | | | C.Wi.g: | C.Wi.g: | |
| | | | 7 years =25.70 | 7 years =25.63 | |
| | | | 10 years =26.26 | 10 years =26.32 | |
| | | | 12 years =26.02 | 12 years =24.96 | |
| | | | 15 years =25.66 | 15 years =24.95 | |
| | | | 32 years =24.91 | 32 years =24.54 | |
| | | | 1PM.Wi.lc: | 1PM.Wi.lc: | |
| | | | 7 years =31.42 | 7 years =31.25 | |
| | | | 10 years =31.67 | 10 years =31.83 | |
| | | | 12 years =31.44 | 12 years =31.04 | |
| | | | 15 years =31.68 | 15 years =30.99 | |
| | | | 32 years =31.04 | 32 years =30.81 | |
| | | | 2PM.Wi.lc: | 2PM.Wi.lc: | |
| | | | 7 years =35.93 | 7 years =35.34 | |
| | | | 10 years =36.22 | 10 years =35.95 | |
| | | | 12 years =36.67 | 12 years =36.32 | |
| | | | 15 years =36.70 | 15 years =35.92 | |
| | | | 32 years =35.91 | 32 years =35.67 | |
| | | | 1M.Wi.mlc: | 1M.Wi.mlc: | |
| | | | 7 years =40.26 | 7 years =39.87 | |
| | | | 10 years =41.10 | 10 years =40.72 | |
| | | | 12 years =41.71 | 12 years =41.14 | |
| | | | 15 years =41.89 | 15 years =40.94 | |
| | | | 32 years =41.03 | 32 years =40.24 | |
| | | | 1M.Wi.dlc | 1M.Wi.dlc | |
| | | | 7 years =41.80 | 7 years =40.97 | |
| | | | 10 years =42.94 | 10 years =42.29 | |
| | | | 12 years =43.09 | 12 years =42.79 | |
| | | | 15 years =43.41 | 15 years =42.41 | |
| | | | 32 years =42.99 | 32 years =41.98 | |
| | | | 1M.Wi.g: | 1M.Wi.g: | |
| | | | 7 years =32.96 | 7 years =32.96 | |
| | | | 10 years =33.76 | 10 years =33.95 | |
| | | | 12 years =34.72 | 12 years =34.70 | |
| | | | 15 years =35.37 | 15 years =34.78 | |
| | | | 32 years =35.31 | 32 years =34.72 | |

Caption: M=males; F=females; 3D=three-dimensional; 2D=two-dimensional; NS= non-significant

Table 2. Continued...

| Author, year, country | Sample | Instruments | Measurements in males millimeters (mm) | Measurements in females millimeters (mm) | Statistical analysis |
|------------------------------------------------|--------------------------------|--------------------------------------------|---------------------------------------------------|---------------------------------------------|-----------------------------------------------------------------------------------|
| Kumar e Nandlal ⁽¹⁹⁾ India | Control group: 44 subjects | Plaster cast: | 1M.Wi.mbc | 1M.Wi.mbc | Descriptive analysis |
| | M=24 | -Digital caliper | 6-8 years = 48.15 | 6-8 years = 46.40 | |
| | - 10 subjects aged 6 to 8 | -Dial caliper with palatal height gauge | 10-12 years = 51.21 | 10-12 years = 52.89 | |
| | - 14 subjects aged 10 to 12 | | 1M.Le | 1M.Le | |
| | F=20 | | 6-8 years = 26.18 | 6-8 years = 24.40 | |
| | - 7 subjects aged 6 to 8 | | 10-12 years = 30.89 | 10-12 years = 30.77 | |
| | - 13 subjects aged 10 to 12 | | 1M.De | 1M.De | |
| | | | 6-8 years = 13.68 | 6-8 years = 12.9 | |
| | | 10-12 years = 15.78 | 10-12 years = 15.93 | | |
| Rastegar-Lari et al. ⁽²⁰⁾ Kuwait | 143 subjects | Plaster cast: | C.Wi.cus=34.91 | C.Wi.cus=33.63 | Equal letters: differences between genders |
| | M=69 F=74 | -Digital caliper | 1PM.Wi.dg=38.4 | 1PM.Wi.dg=36.63 | |
| | 13-14 years | | 1M.Wi.mbc=52.39 | 1M.Wi.mbc=50.31 | |
| | | | 1M.Wi.cf=48.44 | 1M.Wi.cf=46.11 | |
| | | | 1M.W.g=36.08 | 1M.W.g=34.95 | |
| | | | 1PM.Le=28.43 ^a | 1PM.Le=27.45 ^a | |
| Ribeiro et al. ⁽²¹⁾ Brazil | 19 subjects: | Scanned model: | There was no comparison between males and females | | Equal letters: significant difference between Time 1 and Time 2 |
| | M=7 F=12 | -Measures in 3D image with software | C.Wi.cus: | | |
| | Time 1: | | Time 1=30.94 ^a | | |
| | 6-8.6 years | | Time 2=34.15 ^a | | |
| | Time 2: | | 1M.Wi.cf: | | |
| | 10.10-14.2 years | | Time 1=46;15 ^b | | |
| | | | Time 2=48.31 ^b | | |
| Al-Khatib et al. ⁽²²⁾ Malaysia | 252 subjects: | Scanned model: | C.Wi.cus | C.Wi.cus | Descriptive analysis for ages |
| | M=126 F=126 | --Measures in 3D image with software | 13-14 years=35.4 | 13-14 years = 34.1 | |
| | 3 age groups | | 15-17 years = 35.4 | 15-17 years = 34.3 | |
| | 13-14 years | | 18-30 years = 35.21PM. Wi.bc | 18-30 years = 34.11PM. Wi.bc | |
| | 15-17 years | | 13-14 years = 42.9 | 13-14 years = 41.6 | |
| | 18-30 years | | 15-17 years=43.4 | 15-17 years = 42.3 | |
| | | | 18-30 years = 43.6 | 18-30 years = 42.0 | |
| | | | 2PM.Wi.bc | 2PM.Wi.bc | |
| | | | 13-14 years = 49.4 | 13-14 years = 47.0 | |
| | | | 15-17 years = 49.7 | 15-17 years = 47.6 | |
| | | | 18-30 years = 49.1 | 18-30 years = 47.1 | |
| | | | 1M.Wi.mbc | 1M.Wi.mbc | |
| | | | 13-14 years = 54.1 | 13-14 years = 51.5 | |
| | | | 15-17 years = 54.8 | 15-17 years = 52.4 | |
| | | | 18-30 years = 54.3 | 18-30 years = 51.9 | |
| | | | C.Wi.cus=35.30 ^a | C.Wi.cus=34.10 ^a | |
| | | | 1PM.Wi.bc=43.30 ^b | 1PM.Wi.bc=42.00 ^b | |
| | | 2PM.Wi.bc=49.4 ^c | 2PM.Wi.bc= 47.2 ^c | | |
| | | 1M.Wi.mbc=54.4 ^d | 1M.Wi.mbc=51.9 ^d | | |

Caption: M=males; F=females; 3D=three-dimensional; 2D=two-dimensional; NS= non-significant

Table 2. Continued...

| Author, year, country | Sample | Instruments | Measurements in males millimeters (mm) | Measurements in females millimeters (mm) | Statistical analysis |
|------------------------------------------------------|-----------------------------------|----------------------------------------|-------------------------------------------|---------------------------------------------|--------------------------------------------------------|
| Louly et al. ⁽²³⁾ Brazil | 66 subjects | Plaster cast: | C.Wi.cus: | C.Wi.cus: | Equal letters: differences between genders |
| | M=29 F=37 | -Digital caliper | 9 years =27.99 | 9 years =27.04 | |
| | 9-12 years | -Three-dimensional Korkhaus compass | 10 years =26.72 | 10 years =26.73 | |
| | | | 11 years =26.56 | 11 years =26.91 | |
| | | | 12 years =26.51 | 12 years =25.78 | |
| | | | 1PM.Wi.cg: | 1PM.Wi.cg | |
| | | | 9 years =36.89 | 9 years =35.89 | |
| | | | 10 years =35.28 | 10 years =36.06 | |
| | | | 11 years =35.57 | 11 years =36.14 | |
| | | | 12 years =36.48 | 12 years =36.47 | |
| | | | 1M.Wi.cg: | 1M.Wi.cg: | |
| | | | 9 years =48.06 | 9 years = 45.74 | |
| | | | 10 years =46.69 | 10 years =48.05 | |
| | | | 11 years =47.14 | 11 years =48.47 | |
| | | | 12 years =48.93 | 12 years =47.61 | |
| | | | 2M.Wi.cf: | 2M.Wi.cf: | |
| | | | 10 years =50.70 | 10 years =52.16 | |
| | | | 11 years =52.02 | 11 years =52.98 | |
| | | | 12 years =53.44 | 12 years =53.56 | |
| | | | Max.D.o:9 years =11.0 | Max.D.o:9 years: 9.40 | |
| | | | 10 years =11.71 ^a | 10 years: 9.72 ^a | |
| | | | 11 years =11.0 | 11 years: 10.84 | |
| | | | 12 years =12.20 | 12 years: 10.87 | |
| | | | 1M.Le: | 1M.Le: | |
| | | | 9 years =40.00 | 9 years =38.40 | |
| | | | 10 years =39.00 | 10 years =39.36 | |
| | | | 11 years =39.05 | 11 years =39.76 | |
| | | | 12 years =40.45 | 12 years =39.87 | |
| | | | C.Le: | C.Le: | |
| | | | 9 years =14.50 | 9 years =13.30 | |
| | | | 10 years =13.57 | 10 years =14.09 | |
| | | | 11 years =14.27 | 11 years =14.63 | |
| | | | 12 years =15.37 | 12 years =15.12 | |
| | | | 1M.Le-C.Le: | 1M.L-C.Le: | |
| | | | 9 years =25.5 | 9 years =25.10 | |
| | | | 10 years =24.42 | 10 years =25.27 | |
| | | | 11 years =24.77 | 11 years =25.13 | |
| | | | 12 years =25.08 | 12 years =24.75 | |
| Lombardo et al. ⁽²⁴⁾ Italian and Spain | 58 southern European subjects: | Scanned model: | C.Wi.g=27.1 | C.W.g=26.6 | N.S. Between genders |
| | M=21 F=37 | -Measures in 2D image with software | 1M.Wi.g=36.7 | 1M.W.g=36.9 | |
| | 19-70 years | | 2M.Wi.g=42.2 | 2M.W.g=42.4 | |
| | | | C.Le.g= 6.9 | C.Le.g=6.6 | |
| | | | 1M.Le.g=29.3 | 1M.L.g=28.9 | |
| Slaj et al. ⁽²⁵⁾ Croatia | 43 subjects | Scanned model: | C.Wi.buc= 37.51 | C.Wi.cus=36.38 | Descriptive analysis |
| | Angle Class I | -Measures in 3D image with software | 1M.Wi.buc=56.22 | 1M.Wi.buc=54.37 | |
| | M=19 F=24 | | 1M.Le=9.50 | 1M.Le=8.59 | |
| | 15-18 years | | 1M.L =32.48 | 1M.L =30.96 | |
| | | | | | |
| Arslan et al. ⁽²⁶⁾ Turkey | 65 subjects | Plaster cast: | C.Wi.cus=31.97 | C.Wi.cus=31.29 | Equal letters: differences between genders |
| | M=29 F=36 | - Digital caliper | 1PM.Wi.cg=35.55 ^a | 1PM.Wi.cg=34.43 ^a | |
| | Mean age: | | 1M.Wi.cf=45.84 ^b | 1M.Wi.cf=44.15 ^b | |
| | M= 9.44 years | | 1M.Le=28.16 | 1M.Le=26.88 | |
| | F=9.74 years | | | | |

Caption: M=males; F=females; 3D=three-dimensional; 2D=two-dimensional; NS= non-significant

Table 2. Continued...

| Author, year, country | Sample | Instruments | Measurements in males millimeters (mm) | Measurements in females millimeters (mm) | Statistical analysis |
|-------------------------------------------------|------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|-------------------------------------------|---------------------------------------------|--------------------------------------------------------|
| Tsai and Tan ⁽²⁷⁾ China | 150 Taiwanese children | Picture of model: | 2m.Wi.g.R=14.66 ^a | 2m.Wi.g.R=14.18 ^a | Equal letters: differences between genders |
| | M=78 F=72 | | 2m.Wi.g.L=15.42 ^b | 2m.Wi.g.L=14.68 ^b | |
| | 4-5 years | -Measures taken with software | 2m.De.g=10.77 | 2m.De.g=10.67 | |
| | | | 2m.Wi.mlc=34.73 ^c | 2m.Wi.mlc=33.18 ^c | |
| Hsu ⁽²⁸⁾ Taiwan | Control group | Width: Photocopied and printed image of the occlusal face of the cast | 1M.Wi.cf=49.81 | 1M.Wi.cf=48.73 | Descriptive analysis |
| | M= 30 | Depth: Model cut at the level of the central fossa of the 1st molars and distal base copied and printed | 1PM.Wi.dg= 32.91 | 1PM.Wi.dg= 32.09 | |
| | 12.8-18.3 years | - Measurements on printed sheets with digital caliper | 1M.De= 20.66 | 1M.De= 20.99 | |
| | (Mean 14.3) | | | | |
| | F=30 | | | | |
| | 12.9-19.1 years | | | | |
| | (Mean 14.4) | | | | |
| Bishara et al. ⁽²⁹⁾ United States | Two groups: | Dental casts: | Anterior.Wi.g: | Anterior.Wi.g: | Equal letters: |
| | 6 weeks - 2 years | - Dial caliper (Dial caliper) | 6 weeks=26.3 ^a | 6 weeks: 25.3 ^l | Significant difference between ages |
| | M=33 F=28 | | 1 year=28.6 ^{a,b} | 1 year: 27.3 ^{lm} | Difference between genders in all ages |
| | Assessments with 6 weeks, 1 and 2 years | | 2 years =30.5 ^b | 2 years: 29.3 ^m | |
| | 3-45 years | | Posterior.Wi.g: | Posterior.Wi.g: | |
| | M=15 F=15 | | 6 weeks: 27.4 ^c | 6 weeks=26.9 ⁿ | |
| | Assessments at 3, 5, 8, 13, 26 and 45 years | | 1 year=30.1 ^{c,d} | 1 year=29.1 ^{n,o} | |
| | | | 2 years =32.7 ^d | 2 years=30.8 ^o | |
| | | | c.Wi.cus or C.Wi.cus: | c.Wi.cus or C.Wi.cus: | |
| | | | 3 years=28.8 ^e | 3 years=27.4 ^p | |
| | | | 5 years=30.3 ^{e,f} | 5 years=28.4 ^{p,q} | |
| | | | 8 years=32.5 ^{f,g} | 8 years=30.7 ^{q,r} | |
| | | | 13 years=35.1 ^g | 13 years=33.1 ^r | |
| | | | 26 years =34.0 | 26 years=32.3 ^s | |
| | | | 45 years =33.7 | 45 years=31.9 ^s | |
| | | | 2m.Wi.mbc or 1M.Wi. mbc: | 2m.Wi.mbc or 1M.Wi. mbc: | |
| | | | 3 years=40.9 ^h | 3 years=39.3 ^t | |
| | | | 5 years= 43.5 ^{h,i} | 5 years=40.8 ^{t,u} | |
| | | | 8 years=51.0 ^{ij} | 8 years=48.1 ^{u,v} | |
| | | | 13 years=53.4 ^j | 13 years=50.1 ^{v,x} | |
| | | | 26 years =53.6 | 26 years=48.3 ^x | |
| | | | 45 years = 53.4 | 45 years =48.4 | |

Caption: M=males; F=females; 3D=three-dimensional; 2D=two-dimensional; NS= non-significant

Chart 1. Description of the measurements made in the studies, standardization of the nomenclature and abbreviation for data extraction

| Author year | Description of measurements in the maxillary dental arch according to the selected papers | Standardized nomenclature and abbreviations used in this Review |
|-------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Mina et al. ⁽¹²⁾ | <ol style="list-style-type: none"> 1. Intermolar width: distance between the buccal grooves of the 1st permanent molars. 2. Molar depth: distance between the contact point of the central incisors and the line connecting the 1st permanent molars. | <ol style="list-style-type: none"> 1. Width of the maxillary 1st molar between the buccal grooves (1M.Wi.bg). 2. 1st molar length: (1M.Le) |
| Patel and Daruwala ⁽¹³⁾ | <ol style="list-style-type: none"> 1. Inter canine width: distance between canine cusps. 2. Width between 2nd molars: distance between the distobuccal cusps of the 2nd molars. 3. Canine depth: distance between the contact point of the central incisors and the line connecting the canine cusps. 4. 2nd molar depth: distance between the contact point of the central incisors and the line connecting the distobuccal cusps of the 2nd molars. | <ol style="list-style-type: none"> 1. Maxillary canine width between cusps (C.Wi.cus). 2. Maxillary 2nd molar width between the distobuccal cusps (2M.Wi.dbc). 3. Maxillary canine length (C.Le). 4. Maxillary 2nd molar length (2M.Le). |
| Shahid et al. ⁽¹⁴⁾ | <ol style="list-style-type: none"> 1. Inter canine width: distance between canine cusps. 2. Length between 1st premolars: distance between the buccal cusps of the 1st premolars. 3. Length between 2nd premolars: distance between the buccal cusps of the 2nd premolars. 4. Width between 1st molars: distance between the mesiobuccal cusps of the 1st molars. | <ol style="list-style-type: none"> 1. Maxillary canine width between cusps (C.Wi.cus). 2. Width of the 1st maxillary premolar between the buccal cusps (1PM.Wi.bc). 3. Width of the 2nd maxillary premolar between the buccal cusps (2PM.Wi.bc). 4. Width of the 1st molar maxillary between the mesiobuccal cusps (1M.Wi.mbc). |
| Hasegawa et al. ⁽¹⁵⁾ | <ol style="list-style-type: none"> 1. Inter canine lingual: distance between the canines at the intersection of the gingival rim and the long axis of the tooth. 2. Inter premolar lingual: distance between the 1st premolars at the intersection of the gingival rim and the long axis of the tooth. 3. Intermolar lingual: distance between 1st molars at the gingival level of the lingual groove. 4. Intermolar central: distance between the central fossa of the 1st molars. 5. Coronal arch length: measured between the most anterior point of the gingiva in the mesial contact area of the central incisors and the most distal point of the 1st molars. 6. Basal arch length: measured between the distal point of the 1st molars and the most anterior point of the basal arch. 7. Basal arch width: measured between the most concave point of the basal bone in the area of the 1st premolars. | <ol style="list-style-type: none"> 1. Canine width between points at the gingival level (C.Wi.g). 2. Width of the 1st premolar between points at the gingival level (1PM.Wi.g). 3. Width of the 1st molar between points at the gingival level (1M.Wi.g). 4. Width of the maxillary 1st molar between the central fossa (1M.Wi.cf). 5. 1st molar length (1M.Le). 6. Basal arch length (1M.LeB). 7. Basal length (1PM.WiB). |
| Ahn et al. ⁽¹⁶⁾ | <ol style="list-style-type: none"> 1. Inter canine width: distance between crown cusps of deciduous or permanent canines. | <ol style="list-style-type: none"> 1. Maxillary canine width between the cusps of deciduous canines (c.Wi.cus). 2. Maxillary canine width between permanent canine cusps (C.Wi.cus). |
| Celebi et al. ⁽¹⁷⁾ | <ol style="list-style-type: none"> 1. Inter premolar Width: distance between the central grooves of the 1st premolars. 2. Intermolar Width: distance between the central fossa of the 1st molars. | <ol style="list-style-type: none"> 1. Width of the 1st maxillary premolar between the central grooves (1PM.Wi.cg). 2. Width of the maxillary 1st molar between the central fossae (1M.Wi.cf). |
| Heikinheimo et al. ⁽¹⁸⁾ | <ol style="list-style-type: none"> 1. Inter canine width: <ol style="list-style-type: none"> a) distance between the canine cusps; b) distance between the canines measured through the intersection of the gingival rim and the long axis of the tooth. 2. Inter-bicuspid width of the 1st premolar: distance between the lingual cusps of the 1st premolars; 3. Inter-bicuspid width of the 2nd premolar: distance between the lingual cusps of the 2nd premolars; 4. Intermolar Width: <ol style="list-style-type: none"> a) distance between the mesiolingual cusps; b) distance between the distolingual cusps; c) distance from the gingival rim to the level of the mesiolingual cusps. | <ol style="list-style-type: none"> 1. Maxillary canine width: <ol style="list-style-type: none"> a) between the cusps (C.Wi.cus). b) at the gingival level (C.Wi.g). 2. Width of the 1st maxillary premolar between the lingual cusps (1PM.Wi.lc). 3. Width of the 2nd maxillary premolar between the lingual cusps (2PM.Wi.lc). 4. Width of the maxillary 1st molar (1M.Wi): <ol style="list-style-type: none"> a) between the mesiolingual cusps (1M.Wi.mlc); b) between the distolingual cusps (Wi.1M.dlc); c) between points at the gingival level (1M.Wi.g). |

Chart 1. Continued...

| Author year | Description of measurements in the maxillary dental arch according to the selected papers | Standardized nomenclature and abbreviations used in this Review |
|--------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Kumar and Nandlal⁽¹⁹⁾ | <ol style="list-style-type: none"> 1. Intermolar width: maximum rectilinear distance between the tips of the mesiobuccal cusps of the 1st molars. 2. Maxillary arch length: distance from the line connecting the 1st molars to the labial surface of the central incisors. 3. Palate depth: from the line corresponding to the intermolar distance to the palate. | <ol style="list-style-type: none"> 1. Width of the maxillary 1st molar between the mesiobuccal cusps (1M.Wi.mbc). 2. 1st molar length (1M.Le). 3. Depth of the maxillary 1st molar (1M.De). |
| Rastegar-Lari et al.⁽²⁰⁾ | <ol style="list-style-type: none"> 1. Width between canines: distance between canine cusps. 2. Width between the 1st premolars: distance between the distal groove of the 1st premolar. 3. Width between the 1st molars: <ol style="list-style-type: none"> a) distance between the mesiobuccal cusps of the 1st molars; b) distance between the central fossa of the 1st molars; c) distance between the midpoint of the lingual faces of the 1st molars. 4. Arch length: from the point of contact between the central incisors to the line connecting the mesial point of the 1st premolars. | <ol style="list-style-type: none"> 1. Maxillary canine width between cusps (C.Wi.cus). 2. Width of the maxillary 1st premolar between the distal grooves (1PM.Wi.dg). 3. Width of the maxillary 1st molar (1M.Wi): <ol style="list-style-type: none"> a) between the mesiobuccal cusps (1M.Wi.mbc); b) between the central fossa (1M.Wi.cf); c) at the gingival level (1M.Wi.g). 4. Length of the maxillary 1st premolar (1PM.Le). |
| Ribeiro et al.⁽²¹⁾ | <ol style="list-style-type: none"> 1. Inter canine width: distance between canine cusps. 2. Intermolar width: distance between the midpoint of the mesiopalatal, distopalatal, mesiobuccal and distobuccal cusps. | <ol style="list-style-type: none"> 1. Maxillary canine width between cusps (C.Wi.cus). 2. Maxillary 1st molar width between the central fossa (1M.Wi.cf). |
| Al-Khatib et al.⁽²²⁾ | <ol style="list-style-type: none"> 1. Inter canine distance: distance between canine cusps. 2. Inter-1st premolar distance: distance between the buccal cusps of the 1st premolars. 3. Inter-2nd premolar distance: distance between the buccal cusps of the 2nd premolars. 4. Intermolar distance: distance between the mesiobuccal cusps of the 1st molars. | <ol style="list-style-type: none"> 1. Maxillary canine width between cusps (Wi.Ca.cus). 2. Width of the maxillary 1st premolar between buccal cusps (1PM.Wi.bc). 3. Width of the maxillary 2nd premolar between buccal cusps (2PM.Wi.bc). 4. Width of the maxillary 1st molar between the mesiobuccal cusps (1M.Wi.mbc). |
| Louly et al.⁽²³⁾ | <ol style="list-style-type: none"> 1. Inter canine width: distance between canine cusps. 2. Inter 1st premolar width: distance between the central grooves of the 1st premolars. 3. Inter 1st molar width: distance between the central grooves of the 1st molars. 4. Inter-2nd molar width: distance between the central grooves of the 2nd molars. 5. Maxillary depth: from the line that connects the occlusal plane to the greater depth of the palate. 6. Total arch length: perpendicular distance from the line connecting the central incisors and the upper point of the palatine raphe to the line that measures the depth at the level of the 1st molars. 7. Length of the anterior arch segment: perpendicular distance from the line connecting the central incisors to the line connecting the distal surfaces of the canines. 8. Length of the posterior arch segment: difference between the total length of the arch and the length of the anterior segment. | <ol style="list-style-type: none"> 1. Maxillary canine width between cusps (C.Wi.cus). 2. Width of the maxillary 1st premolar between the central grooves (1PM.Wi.cg). 3. Width of the maxillary 1st molar between the central grooves (1M.Wi.cg). 4. Width of the maxillary 2nd molar between the central grooves (2M.Wi.cg). 5. Maximum maxillary depth at the level of the occlusal plane (Max.De.o). 6. Maxillary 1st molar length (1M.Le). 7. Maxillary canine length (C.Le). 8. Difference between maxillary 1st molar length and maxillary canine length (1M.Le- C.Le). |
| Lombardo et al.⁽²⁴⁾ | <ol style="list-style-type: none"> 1. Inter canine diameter: distance between the most prominent points in the central axis of the lingual surface of the canine crown. 2. Intermolar diameter at the 1st molar level: distance between the most prominent points of the lingual surface of the 1st molars in the center of the clinical crown. 3. Intermolar diameter at the level of the 2nd molars: distance between the most prominent points of the lingual surface of the 2nd molars in the center of the clinical crown. 4. Canine depth: is the distance between the point between the central incisors and the line that connects the most prominent points in the central axis of the lingual surface of the canine crown. 5. 1st molar depth: the distance of the point between the central incisors and the line that connects the 1st molars. 6. 2nd molar depth: the distance of the point between the central incisors and the line that connects the 2nd molars. | <ol style="list-style-type: none"> 1. Canine width between points at the gingival level (C.Wi.g). 2. Width of the 1st molar between points at the gingival level (1M.Wi.g). 3. Width of the 2nd molar between points at the gingival level (2M.Wi.g). 4. Gingival canine length (C.Le.g). 5. Gingival 1st molar length (1M.Le.g). 6. Gingival 2nd molar length (2M.Le.g). |

Chart 1. Continued...

| Author year | Description of measurements in the maxillary dental arch according to the selected papers | Standardized nomenclature and abbreviations used in this Review |
|---------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Slaj et al. ⁽²⁶⁾ | 1. Canine width: distance between the clinical points of the canine brackets. 2. Intermolar width: distance between the clinical points of the 1st molar brackets. 3. Canine depth: distance from the line connecting the clinical points of the canine brackets to the point between the central incisors. 4. Molar depth: distance from the line connecting the clinical points of the 1st molar brackets to the point between the central incisors. | 1. Maxillary canine width between the buccal (C.Wi.buc). 2. Maxillary 1st molar width between the buccal (1M.Wi.buc). 3. Maxillary canine length (C.Le). 4. Maxillary 1st molar length (1M.Le). |
| Arslan et al. ⁽²⁶⁾ | 1. Maxillary canine width: distance between canine cusps. 2. Maxillary pre-molar width: distance between the central grooves of the 1st premolars. 3. Maxillary molar width: distance between the points of the central fossa of the 1st molars. 4. Maxillary arch depth: perpendicular distance from the labial surface of the central incisors to the line between the central fossae of the 1st molars. | 1. Maxillary canine width between cusps (Ca.Wi.cus). 2. 1st premolar width between the central grooves (1PM.Wi.cg). 3. Maxillary 1st molar width between the central fossa (1M.Wi.cf). 4. Maxillary 1st molar length (1M.Le). |
| Tsai and Tan ⁽²⁷⁾ | 1. Right-side palatal width: distance between the cervical point of the right deciduous 2nd molar to the point of the perpendicular line in the palatine raphe. 2. Left-side palatal width: distance between the cervical point of the left deciduous 2nd molar to the point of the perpendicular line in the palatine raphe. 3. Palate depth: distance between the point of the palatine raphe to the line connecting the 2nd deciduous molars to the gingival level. 4. Dental arch width: Distance between the mesiolingual cusps of the upper deciduous 2nd molars. | 1. Width of the deciduous 2nd molar from the point to the gingival level on the right side (2m.Wi.g.R) 2. Width of the deciduous 2nd molar from the point to the gingival level on the left side (2m.Wi.g.L) 3. Gingival palatine depth (2m.De.g). 4. Deciduous 2nd molar width between mesiolingual cusps (2m.Wi.mlc). |
| Hsut ⁽²⁸⁾ | 1. Upper intermolar width: distance between the central fossa of the upper 1st molars. 2. Upper interpremolar width: distance between the distal grooves of the upper 1st premolars. 3. Palate depth: distance from the deepest part of the palate to the line connecting the central fossae of the upper 1st molars. | 1. Maxillary 1st molar width between the central fossa (1M.Wi.cf). 2. Maxillary 1st premolar width between the distal grooves (1PM.Wi.dg). 3. Maxillary 1st molar depth (1M.De). |
| Bishara et al. ⁽²⁹⁾ | 6 weeks - 2 years 1. Anterior maxillary arch width: distance between lateral groove points at the alveolar ridge level. 2. Posterior maxillary arch width: distance between the points of the posterior margin of the gingiva at the alveolar ridge level. 3 - 45 years 1. Inter canine width: distance between the tips of the canine cusps. 2. Deciduous intermolar width: distance between the tips of the mesiobuccal cusps of the 2nd deciduous molars (3 to 5 years). 3. Permanent intermolar width: distance between the tips of the mesiobuccal cusps of the 1st permanent molars for all subsequent ages. | 1. Anterior maxillary width between the points at the gingival level (Anterior.Wi.g). 2. Posterior maxillary width between the points at the gingival level (Posterior.Wi.g). 1. Maxillary canine width between cusps (C.Wi.cus). 2. Deciduous 2nd molar width between the mesiobuccal cusps (2m.Wimbc). 3. Permanent 2nd molar width between the mesiobuccal cusps (2M.Wi.mbc). |

with software^(12-14,16,21,22,24,25,27); and in printed copies of the models, measurements were performed with a digital caliper⁽²⁸⁾.

Most of the reference points used for measurements used some anatomical point of the teeth (maxillary dental arch dimensions) while in only six studies^(15,18,20,24,27,29) at least one measurement was based on some point in the gingival edge, which allowed hard palate dimensions to be determined. All studies considered the transverse plane while making the measurements, while nine also made measurements on the sagittal plane^(12,13,15,19,20,23-26) and four, on the vertical plane^(19,23,27,28).

Analysis of hard palate or maxillary dental arch dimensions according to gender and age

The 18 studies included in this review were published between 1997 and 2016. Thirteen had a cross-sectional design^(12-15,17,19,20,22-25,27,28), while five had a longitudinal design^(16,18,21,26,29). Eleven studies

reported hard palate or maxillary dental arch dimensions according to gender^(12-15,17,20,24-28), six according to age and gender^(16,18,19,22,23,29) and only one study showed hard palate dimensions according to age range⁽²¹⁾ (Table 2).

There were some findings after analysis of information intended for comparison of hard palate and maxillary dental arch dimensions as far as gender is concerned (Table 2). A study made a comparison between boys and girls with deciduous teeth (children aged 4 to 5 years)⁽²⁷⁾ and found that Chinese boys showed greater maxillary width, as well as higher left and right maxillary width at the level of the second deciduous molars than girls, but there was no difference in hard palate depth.

Another study was conducted with a sample with mean age of nine years for both boys and girls⁽²⁶⁾. Boys had significantly higher maxillary width at the level of the first premolars and molars, but there was no difference between boys and girls in

maxillary width between the canines and in anteroposterior maxillary length until the first molars. In the mixed dentition phase, one of the studies found significantly higher hard palate in boys only at ten years of age⁽²³⁾.

The analysis of the studies described in Table 2 showed that virtually all the means of the measurements performed in the transverse plane (width), regardless of the point of reference in use, were higher in males. As regards studies that made a statistical analysis to compare the values found in the transverse plane (width) between males and females in the permanent dentition phase, it was found that five^(13-15,22,29) found a significant difference between males and females, while four others^(12,17,20,24) showed no difference.

Of the 12 studies performed with subjects in the permanent dentition phase addressing a comparison between genders^(12-15,17,18,20,22,24,25,28,29), six made at least one measurement of the maxillary dental arch on the sagittal plane (length)^(12,13,15,20,24,25). Five of such studies compared differences in maxillary length between genders^(12,13,15,20,24).

As regards the results found in these five studies, Hasegawa et al.⁽¹⁵⁾ found that hard palate length until the level of the first molars was significantly greater in Mongolian women while anteroposterior maxillary length was significantly greater in Japanese males. Two studies found significantly higher maxillary length in males^(13,20), while the other two^(12,24) found no difference.

During measurements on the vertical plane (depth) in the permanent dentition phase, only one study had measured maxillary depth of the first molars, and the means were very similar between genders⁽²⁸⁾.

With respect to hard palate or maxillary dental arch dimensions according to age, most of the studies made only a descriptive analysis of the results^(18,19,22) or an analytical statistical analysis for

comparison between genders at different ages^(16,23). A statistical comparison between measurements at different ages was only made in two studies^(21,29).

The longitudinal study of Ribeiro et al.⁽²¹⁾ found that the width values of the maxillary dental arch between the canines and first premolars in the age range of 10 to 14 years were significantly higher than those of children aged six to eight years. The difference between the two periods was equal to 3.21 mm in width between the canines and 2.16 mm in width between the first molars⁽²¹⁾.

Finally, Bishara et al.⁽²⁹⁾ made a longitudinal evaluation of subjects from birth to 45 years of age through measurements on the transverse plane (width). From six weeks to two years of age, i.e., from the period of gingival rims until deciduous dentition, there was an increase of 4.2 mm of the average width of the anterior hard palate in boys and 4.0 mm in girls, as well as an increase of 5.3 mm in the width of the posterior hard palate in boys and 3.9 mm in girls. From three up to 13 years of age, width of the anterior and posterior maxillary arch has gradually increased, and there was statistical significance between ages. From three to five years, average width between the canines increased by 1.5 mm in boys and 1.0 in girls, and from eight to 13 years, it increased by 2.6 mm and 2.4 mm in boys and girls, respectively. Average width between the second deciduous molars from three to five years increased by 2.6 mm in boys and 1.5 mm in girls, while the average between the first permanent molars increased by 2.4 mm in boys and 2.0 mm in girls from eight to 13 years of age. Moreover, in women from 26 to 45 years, there was a decrease in width between the canines, and from 13 to 26 years, width decreased between the first molars. In the present study, all the averages of the measurements made at different ages were significantly higher in males⁽²⁹⁾.

Table 3. Internal quality and risk control of bias according to the "Newcastle - Ottawa Quality" Scale

| Author | Design | Selection | Comparability | Result | Total |
|--------------------------------------|-----------------|-----------|---------------|--------|--------|
| Mina et al. ⁽¹²⁾ | Cross-sectional | ★★ | ★ | ★ | 4 (10) |
| Patel and Daruwala ⁽¹³⁾ | Cross-sectional | ★ | ★ | ★ | 3 (10) |
| Shahid et al. ⁽¹⁴⁾ | Cross-sectional | ★★ | ★ | ★ | 4 (10) |
| Hasegawa et al. ⁽¹⁵⁾ | Cross-sectional | ★★★ | ★ | ★ | 5 (10) |
| Ahn et al. ⁽¹⁶⁾ | Longitudinal | ★★ | ★ | ★★ | 5 (9) |
| Celebi et al. ⁽¹⁷⁾ | Cross-sectional | ★★★ | ★ | ★ | 5 (10) |
| Heikinheimo et al. ⁽¹⁸⁾ | Longitudinal | ★★★ | ★ | ★ | 5 (9) |
| Kumar and Nandlal ⁽¹⁹⁾ | Cross-sectional | ★ | ★★ | ★ | 4 (10) |
| Rastegar-Lari et al. ⁽²⁰⁾ | Cross-sectional | ★★★ | ★ | ★ | 5 (10) |
| Ribeiro et al. ⁽²¹⁾ | Longitudinal | ★★ | ★ | ★ | 4 (9) |
| Al-Khatib et al. ⁽²²⁾ | Cross-sectional | ★★★ | ★ | ★ | 5 (10) |
| Louly et al. ⁽²³⁾ | Cross-sectional | ★★★ | ★ | ★ | 5 (10) |
| Lombardo et al. ⁽²⁴⁾ | Cross-sectional | ★★ | ★ | ★ | 4 (10) |
| Slaj et al. ⁽²⁵⁾ | Cross-sectional | ★ | ★ | ★ | 3 (10) |
| Arslan et al. ⁽²⁶⁾ | Longitudinal | ★★ | ★ | ★ | 4 (9) |
| Tsai and Tan ⁽²⁷⁾ | Cross-sectional | ★ | ★ | ★ | 3 (10) |
| Hsu ⁽²⁸⁾ | Cross-sectional | ★ | ★ | ★ | 3 (10) |
| Bishara et al. ⁽²⁹⁾ | Longitudinal | ★★ | ★★ | ★ | 5 (9) |

Caption: ★=one point; ★★=two points; ★★★=three points

Evaluation of quality and risk of bias

The score for the analysis of internal quality and control of bias is based on the “*Newcastle - Ottawa Quality*” scale (Table 3). It ranged between three and five for studies with a cross-sectional design (maximum of 10 points) and between four and five in studies with a longitudinal design (maximum of 9 points). Whereas a higher score represents a better quality and lower risk of bias, the studies analyzed in this systematic review had low to intermediate quality.

CONCLUSION

The averages of width measurements of the hard palate and the dental maxillary arch were higher in males in the majority of studies, and most of the selected articles found some significant difference between genders.

In two of the studies that investigated the influence of age on hard palate or maxillary dental arch dimensions, there was statistical difference between the measurements according to age or age range. This suggests the influence of age on the transverse dimensions of the maxillary dental arch.

A comprehensive analysis of the results showed that, as expected, the average reference values gradually increased since birth until approximately the ages between 12 and 15 years, a period which corresponds to the permanent dentition. There are some reference values (expressed as average) from convenience a sample, which limits the extrapolation of these results to other populations. In addition, values of the measurements on the transverse plane outnumber those on the vertical and sagittal planes.

All studies were based on plaster casts, and the measurements were performed directly on the models, on scanned models or on printed images. The instruments used for making such measurements were calipers, a three-dimensional compass and software.

Reference parameters found for quantitative analysis of the hard palate according to gender and age, especially in the Brazilian population, are still scarce. In addition, few studies so far have used reference points based on the gingival edge, as well as the vertical and sagittal planes, to make measurements of the hard palate. As a result, further research should address the quantitative assessment of the hard palate according to gender and age on representative samples of Brazilian population. This way, quantitative evaluation of the hard palate can be possibly used to support anthroposcopic assessment in clinical practice.

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Author contributions

LCB was responsible for data collection, tabulation and analysis and drafting the article; MM was responsible for data collection and analysis and drafting the article; JMM and MMM were responsible for data analysis and drafting the article; TMA and AMTS gave general advice on the stages of drafting the article and writing the final version.