Craniofacial Characteristics of Syrian and Hungarian Adolescents with Class II Division 1 Malocclusion

Summary of the PhD Thesis

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1 List of publications

Publications providing the basis of the thesis:

I- Al Ayoubi, Alaa✉; Dalla Torre, Daniel; Madléna, Melinda✉. Craniofacial characteristics of Syrian adolescents with Class II division 1 malocclusion: a retrospective study. PeerJ 8 Paper: e9545, 18 p. (2020). **Q1, IF = 2.379, Citations: 2 (Independent Citations: 1)**

II- Al Ayoubi, Alaa ✉; Khandan Dezfully, Alireza; Madléna, Melinda ✉. Dentoskeletal and tooth-size differences between Syrian and Hungarian adolescents with Class II division 1 malocclusion: a retrospective study. BMC Research Notes 13: 1 Paper: 270, 7 p. (2020). **Q2, Citations: 3 (Independent Citations: 2)**

III- Al Ayoubi, Alaa ✉; Madléna, Melinda ✉
Upper airway characteristics in young individuals with Class II division 1 malocclusion: A retrospective inter-ethnic cephalometric comparison. (2021). **Accepted (In press).** Journal of Craniofacial Surgery. **Q2, IF = 0.953**

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Publication on another topic:

1- Roland Wirth, Gergely Maróti, Lídia Lipták, Mónika Mester, **Alaa Al Ayoubi**, Bernadett Pap, Melinda Madléna, Janos Minarovits, Kornél L. Kovács ✉
Microbiomes in supragingival biofilms and saliva of adolescents with gingivitis and gingival health. (2021). **In review.** Oral Diseases. **(Q1, IF = 2.613)**

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Citable abstract directly related to the subject of the thesis:

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Lectures directly related to the subject of the thesis:

1- Al Ayoubi, Alaa ✉; Khandan Dezfully, Alireza; Madléna, Melinda. Dentofacial Differences between Syrian and Hungarian Adolescents with Class-II/1 Malocclusion. CED-IADR/NOF. Sept 19-21, 2019. Madrid.

2- Al Ayoubi, Alaa ✉; Khandan Dezfully, Alireza; Madléna, Melinda. Comparison of Dentofacial Characteristics between Syrian and Hungarian Adolescents with Class II division 1 malocclusion. 2019. 8th Symposium of Hungarian Society of Orthodontics and Pediatric Dentistry. Nov 7-8, 2019. Siklós.

3- Al Ayoubi, Alaa ✉; Khandan Dezfully, Alireza; Madléna, Melinda. Assessment of dentofacial characteristics in Middle Eastern (Syrian) young orthodontic patients with angle class II division 1 malocclusion. 2018. Symposium: "Research in oral cavity – from basic science to clinical use" organized within the framework of conference EFOP-3.6.2-16-2017-00006. 22-23, 2018. Budapest.

4- Al Ayoubi, Alaa ✉; Khandan Dezfully, Alireza; Madléna, Melinda. Assessment of Dentofacial Characteristics in Middle Eastern (Syrian) Young Orthodontic Patients with Angle Class II Division 1 Malocclusion. 2018. 22nd Congress of the Hungarian Association for Cranio-Maxillo-Facial Surgery and Scientific Meeting of Dentists. Sept 27-29, 2018. Szeged.

2 Introduction

In orthodontics, it is essential to understand the complex relationship between skeletal, dental, and soft tissue aberrations in each malocclusion to achieve an accurate diagnosis followed by an optimal treatment plan.

Class II division 1 (Class II/1) malocclusion has been suggested as one of the most frequent pathologies that orthodontists may encounter in their practice. According to epidemiologic studies conducted among different populations, the prevalence of this malocclusion ranges from 12% to 40% worldwide.

It is well established that Class II/1 malocclusion can be caused by a broad range of factors. However, conflicting results, possibly due to ethnic variations, have not allowed the general characterization of this malocclusion. Likewise, ethnic differences have been observed in tooth-size ratios and upper airway morphology. Moreover, Class II/1 malocclusion presents with a considerable number of features associated with obstructive sleep apnea (OSA), and these features may vary among ethnicities.

Ethnic differences in cephalometric and tooth-size characteristics have been documented in several studies, but only few studies have investigated these differences with respect to Class II/1 malocclusion. This malocclusion is one of the most frequently seen orthodontic anomalies in Syrian and Hungarian

populations with prevalences of 16% and 23.5% in Syrian and Hungarian adolescents, respectively.

Because of recent wars and conflicts, such as the Syrian conflict, ethnic diversity is increasing worldwide. During the last few years, Syrian refugees and immigrants have occupied the foreground of migration statistics, particularly in Europe. Data show that the population of Syrian immigrants reached 8.2 million in 2019 and are considered to be among the fastest-growing populations of ethnic minorities. Such a view of recent trends in migration, especially from the Middle East toward Europe, underscores the need for updated studies to discover the craniofacial characteristics of these new immigrants and compare the cephalometric and tooth-size characteristics between different ethnic groups.

Although some research has considered some cephalometric and tooth-size norms of Syrian populations, or some cephalometric and tooth-size characteristics of Hungarian populations, limited data are available for the characteristics of Syrian adolescents with Class II/1 malocclusion and no study has compared the cephalometric and tooth-size characteristics between Syrian and European adolescents. This comparison would help orthodontists to optimize their treatment planning, considering the ethnic differences between Syrian and Hungarian orthodontic patients regarding their craniofacial and dental characteristics.

3 Objectives

- The first objective of this thesis is to elucidate the cephalometric and tooth-size characteristics of Syrian adolescents with skeletal and dental Class II/1 malocclusion and compare the acquired data with those of Syrian population norms.
- The second objective of this thesis is to compare the dentoskeletal and tooth-size characteristics between Middle Eastern (Syrian) and European (Hungarian) adolescents with skeletal and dental Class II/1 malocclusion.
- The third objective of this thesis is to compare the upper airway structures between Middle Eastern (Syrian) and European (Hungarian) adolescents with skeletal and dental Class II/1 malocclusion, and to investigate a number of skeletal and soft tissue parameters that would be associated with the upper airway depths in each ethnic group.

4 Materials and Methods

All procedures of the retrospective investigations presented in this thesis were approved by the Human Investigation Review Board at the University of Szeged (151/2018-SZTE) and the investigations were designed in accordance with the Declaration of Helsinki. Written informed consent to participate in these studies was provided by the participants' parent or legal guardian or next of kin.

As a consequence of the sample size planning, lateral cephalograms and dental casts of 86 untreated patients with skeletal and dental Class II/1 malocclusion were included. The total sample consisted of two groups based on ethnicity: Group 1 (n = 43) was composed of Syrian patients selected from a private orthodontic office in Damascus, Syria, and group 2 (n = 43) was composed of Hungarian patients selected from the Department of Orthodontics and Pediatric Dentistry, Faculty of Dentistry, University of Szeged, Hungary, including 24 females and 19 males in each ethnic group. Each patient in group 1 was matched with a patient in group 2 by sex and skeletal age.

The criteria for inclusion were as follows:

Age of between 12 and 17 years, Syrian origin for Syrian group and Hungarian origin for Hungarian group, overjet of larger than 4 mm with an absence of upper incisor retroclination, permanent dentition with bilateral distal occlusion (half-unit or greater), ANB angle greater than 4° with a convex facial profile, Absence of extractions or interproximal caries/restorations or any other condition that affected the mesio-distal diameter of the teeth.

Patients with craniofacial syndromes or a history of trauma as well as previous orthodontic treatment were excluded. Additionally, we excluded patients with cephalograms in which a swallowing action or obvious hyperplasia of tonsils and adenoids was detected.

When cephalometric and tooth-size characteristics of Syrian adolescents with Class II/1 malocclusion were compared with Syrian population norms, the Syrian normative cephalometric and tooth-size measurements were obtained from two previous studies used as sources of Syrian normative measurements.

Pretreatment lateral cephalograms were obtained for each patient in both ethnic groups using the same protocol: head in the natural position and the teeth in maximal intercuspation. A dental radiograph system (PAX 400; Vatech Co., Hawseong, Korea) was used to acquire cephalograms for Class II/1 Syrian Samples. The same X-ray machine was used to acquire cephalograms for the Syrian normative cephalometric sample using the same protocol. Another dental radiograph system (Gendex (GXDP-800™); Hatfield, PA, USA) was used to acquire cephalograms for Class II/1 Hungarian Samples. Because the cephalograms for Class II/1 Syrian samples and Class II/1 Hungarian samples were acquired with two different machines, the magnification was corrected to 1:1 using a special orthodontic software program (OnyxCeph3™, Image Instruments GmbH, Chemnitz, Germany). Each cephalogram was digitized, calibrated, and analyzed by one investigator using the above-mentioned special orthodontic software program (OnyxCeph3™).

In order to investigate potential upper airway obstructions in Syrian adolescents with Class II/1

malocclusion, upper-pharyngeal widths were computed for all Class II/1 Syrian subjects whose values were equal to 5 mm or less according to McNamara (1984).

Regarding orthodontic cast analyses and measurements, the mesiodistal crown diameters of all teeth from the right first permanent molar to the left first permanent molar on each cast were measured to the nearest 0.01 mm by one investigator using a universal digital caliper (MIB Messzeuge GMBH, Spangenberg, Germany). The measurements were conducted according to the methods described by Seipel (1946), and Moorrees and Reed (1964). The same method was used in the Syrian normative tooth-size study. Bolton's anterior and overall ratios were calculated and used in the statistical analyses.

In order to investigate the clinical significance of the potential deviations from norms in the tooth-size ratios of Class II/1 Syrian subjects, overall and anterior ratios were computed for all Syrian subjects with Class II/1 malocclusion whose values were outside two SDs from Bolton’s norms and were also computed for all Syrian subjects with Class II/1 malocclusion whose values were outside two SDs from Syrian population norms.

Three approaches were used to assess intra-and inter-examiner reliability. First, Dahlberg’s formula was used to establish the random errors. Second, paired sample t-tests were used to assess the systematic error. Third, intraclass correlation coefficients were calculated for all

variables. Statistical analyses were performed using the SPSS software 24.0 (SPSS Inc., Chicago, USA). The level of statistical significance was $P < 0.05$.

5 Results

5.1 Cephalometric and tooth-size characteristics of Syrian adolescents with Class II/1 malocclusion

Results regarding the sagittal position of the maxilla were as follows: The linear variable (A-NP) showed a value of 0.01 (±2.33) mm [mean (±standard deviation)]. The angular variable (SNA) showed a value of 80.46 (±2.66) degrees. The sagittal mandibular position was determined by one linear variable (Pog-NP) with a value of −11.01 (±4.69) mm. The effective length of the maxilla (Cond-A) was 85.51 (±4.48) mm. The effective length of the mandible (Cond-Gn) was 107.98 (±5.55) mm. The difference between the maxillary length and the mandibular length (Max-Mand) was 22.47 (±4.39) mm.

Results in the vertical plane were as follows: First, lower anterior facial height (ANS-Me) showed a value of 68.30 (±5.09) mm. Second, mandibular plane angle (MP-FH) showed a value of 29.77 (±5.62) degrees. Third, facial axis showed a value of −6.25 (±4.56) degrees.

Results regarding the incisors position were as follows: First, maxillary incisors position (1U-AP) showed a value of 5.86 (±2.05) mm. Second, mandibular incisors position (1L-APog) showed a value of 4.85 (±1.89) mm.

Soft tissue measurements showed an obtuse nasolabial angle (NLA) of 104.05 (±7.42) degrees. Further, the value of the upper-lip angle (UL-NP) was 11.05 (±7.60) degrees.

Regarding upper-airway dimensions, upper and lower-pharyngeal widths were assessed. The upper-pharyngeal width (UPh) was 11.50 (±3.15) mm. The lower-pharyngeal width (LPh) was 10.98 (±2.90) mm. However, there was no prevalence of upper-pharyngeal obstructions (upper-pharyngeal width ≤ 5 mm) in Syrian subjects with Class II/1 malocclusion.

Bolton tooth-size analysis revealed that the anterior ratio was 80.69 (±2.73) percent, while the overall ratio was 92.84 (±1.70) percent.

The percentage of Class II/1 Syrian patients who had anterior ratios greater than two SDs from Bolton's norm [77.2 (±1.65) percent] was 39.5%, whereas the percentage of Class II/1 Syrian patients who had anterior ratios greater than two SDs from Syrian population norm [78.99 (±2.18) percent] was 25.6%. The percentage of Class II/1 Syrian patients who had overall ratios greater than two SDs from Bolton's norm [91.3 (±1.91) percent] was 6.98%, whereas none of Class II/1 Syrian patients had overall ratios greater than two SDs from Syrian population norm [92.26 (±2.06) percent].

Additionally, none of Class II/1 Syrian patients had anterior or overall ratios smaller than two SDs from Bolton's norms, and none of Class II/1 Syrian patients

had anterior or overall ratios smaller than two SDs from Syrian population norms.

5.2 Dentoskeletal and tooth-size differences between Syrian and Hungarian adolescents with Class II/1 malocclusion

Sagittal comparisons revealed that Hungarian males with Class II/1 malocclusion had significantly more protruded maxillae than their Syrian counterparts ($p<0.001$), while Syrian males with Class II/1 malocclusion had significantly more retruded mandibles ($p=0.003$). Additionally, Hungarian females with Class II/1 malocclusion had significantly smaller mandibular lengths than their Syrian counterparts ($p=0.003$).

Vertical measurements showed significant differences ($p<0.001$) between Syrian and Hungarian adolescents with Class II/1 malocclusion, regardless of sex, indicating a hyperdivergent facial pattern in Syrian sample with Class II/1 malocclusion.

Dental measurement results revealed that Syrian females with Class II/1 malocclusion had significantly more protruded lower incisors than Hungarian females with Class II/1 malocclusion ($p<0.001$). These observations did not extend to the male populations with Class II/1 malocclusion.

Tooth-size comparisons revealed that Syrian females with Class II/1 malocclusion had significantly greater anterior tooth-size ratios than Hungarian females with

Class II/1 malocclusion ($p<0.001$). Syrian and Hungarian males with Class II/1 malocclusion showed no such difference.

5.3 Upper airway differences between Syrian and Hungarian adolescents with Class II/1 malocclusion

Comparisons of the upper airway morphology between the two ethnic groups showed that Syrian adolescents with Class II/1 malocclusion had a significantly smaller depth of the upper pharynx ($p=0.007$) and a significantly larger soft palate angle ($p=0.003$) than their Hungarian counterparts, while the hyoid bone was located more posteriorly ($p=0.002$) in Hungarian adolescents with Class II/1 malocclusion than in Syrian adolescents with Class II/1 malocclusion.

Additionally, comparisons of the soft tissue variables related to the upper airway showed that the cervical length was significantly shorter ($p=0.042$), and the lip-chin-throat angle was significantly larger ($p=0.049$) in Hungarian adolescents with Class II/1 malocclusion than in Syrian adolescents with Class II/1 malocclusion.

Correlation analyses revealed several statistically significant and moderate correlations. Indeed, in Syrian subjects with Class II/1 malocclusion, dimensions at the upper level of the pharynx tended to decrease with decreasing SNA, SNB angles ($r=0.34$ and $r=0.31$, respectively) ($p=0.028$ and $p=0.042$, respectively),

decreasing maxillary and mandibular lengths (r=0.47 and r=0.47, respectively) (p=0.002), and increasing inter-maxillary and mandibular plane angles (r=-0.35 and r=-0.31, respectively) (p=0.022 and p=0.047, respectively). Furthermore, in Syrian subjects with Class II/1 malocclusion, dimensions at the middle level of the pharynx tended to decrease with a decreasing SNA angle (r=0.41) (p=0.006), decreasing maxillary length (r=0.32) (p=0.036), and increasing inter-maxillary angle (r=-0.40) (p=0.008).

In contrast to Syrian subjects with Class II/1 malocclusion, Hungarian subjects with Class II/1 malocclusion showed no correlations to sagittal dimensions or any vertical dimension. However, dimensions at the lower level of the pharynx were significantly correlated with hyoid bone position (r=0.41) (p=0.006), cervical length (r=0.46) (p=0.002), and lip-chin-throat angle (r=-0.48) (p=0.001) only among the Hungarian subjects with Class II/1 malocclusion.

6 Summary of New Findings

- A hyperdivergent facial pattern was the main cause of the inter-maxillary discrepancy in Syrian adolescents with Class II/1 malocclusion.
- The observed small pharyngeal widths in Class II/1 Syrian sample were not clinically significant.
- 39.5% of Class II/1 Syrian samples had anterior tooth-size ratios exceeding two SDs of Bolton’s norm

and 25.6% of Class II/1 Syrian samples had anterior tooth-size ratios exceeding two SDs of Syrian population norm, which may be considered as clinically relevant.

- Class II/1 treatment strategies for Hungarian adolescents are not applicable to Syrian adolescents, because.

1. Class II/1 malocclusion reflects sagittal discrepancy in Hungarian adolescents (protruded maxillae in males; short mandibles in females), while it was caused by excessive vertical growth among Syrian adolescents, regardless of sex.
2. Class II/1 Syrian females have more protrusive lower incisors with a relative tooth-size excess in the lower anterior region compared with Class II/1 Hungarian females.

- Ethnic differences were found in upper airway structures between Syrian and Hungarian subjects with Class II/1 malocclusion. Class II/1 Syrian adolescents had a significantly smaller depth of the upper pharynx and a larger soft palate angle than their Hungarian counterparts, while the hyoid bone was located more posteriorly in Class II/1 Hungarian adolescents than in Class II/1 Syrian adolescents.
- An influence of skeletal restriction and vertical growth pattern on the upper and middle pharyngeal airway depths existed in Syrian patients with Class II/1 malocclusion. In contrast, the depths of the pharynx were

generally quite independent of the skeletal parameters in Hungarian subjects with Class II/1 malocclusion.

- The hyoid bone position and soft tissue morphology of the neck and chin regions had an influence on the lower pharyngeal airway depth only among Hungarians with Class II/1 malocclusion.

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