Chin-throat anatomy:
Normal relations and changes following orthognathic surgery
and growth modification

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ABSTRACT

Objectives: To determine if a new facial line (T), tangent to the throat, intersects the mandibular border in anterior (ANT) and posterior (POST) parts in proportions varying with facial configuration, and to evaluate the association between chin projection and throat inclination and the potential for the T-line to reflect this association.

Materials and Methods: Measurements on profile photographs and cephalograms of 135 adults (aged 18–50 years)—45 each of Class I, II, and III (CI, CII, CIII) malocclusions—incorporated ANT and POST, chin-throat (CTA), and mento-cervical (MCA) angles. Pre- and posttreatment measurements were compared in two subgroups (n = 25 each) of CII and CIII orthognathic surgery patients and in CII, division 1 early-treatment patients (n = 63). Statistics included analysis of variance and t-test for group differences, and Pearson correlation for associations among variables.

Results: ANT was nearly equal to POST in CI (50.99%) and CIII (51.86%) subjects and shorter in CII (36.01%) subjects. CTA and MCA were greater in CII profiles and smaller in CIII profiles. Significant differences (P < .0001) were observed for ANT, POST, CTA, and MCA between Classes I/II and II/III and for MCA between Classes II/III (P = .016). High correlations were noted between ANT and CTA in Classes I (r = .83), II (r = .73), and III (r = .68). In surgically treated patients, posttreatment measurements approached CI values. In the early-treatment group, ANT increased but remained smaller than POST; CTA decreased by nearly 13%.

Conclusions: Chin-throat relations and chin extension are associated and require routine assessment in terms of diagnosis and treatment outcome. A practical tool to assess chin-throat relationship, the T-line bisects the mandibular body nearly equally in Class I faces. (Angle Orthod. 2017;87:696–702.)

KEY WORDS: Chin extension; Mandibular border; Throat line; Chin-throat angle

INTRODUCTION

Common cephalometric analyses focus on relations among hard tissues (bone and teeth) and their association with surrounding soft tissues (nose, lips, and chin). Such assessments disregard the influence of the chin-throat relationship on the profile and, consequently, treatment, possibly because of the recognition that this relationship may not be altered with orthodontics. Chin-throat evaluation is more common in plastic surgery, based on clinical and anthropometric normative data, and may be performed directly on patients or on photographs using well-defined soft tissue landmarks. Farkas contributed the most recognized anthropometric age-related data on facial proportions.

Different components define the relation of the chin to the rest of the face:

1. Chin position relative to facial structures, most particularly the lips and/or nose (eg, E-line, Holdaway line, Steiner line), or cranial references
(vertical projections from soft tissue nasion, soft tissue glabella, soft tissue border of the throat (T-line) bisects the body of the mandible in its middle) and minimum overjet of 5 mm. Their ages ranged from 18 to 50 years in boys, 9.32 to 1.45 years in girls).

### 2. Form of the chin "button," evaluated through angular measurements identified differently by various authors: the mento-cervical angle, most notably used by Farkas (78.3° ± 7.9° in males; 83.9° ± 9.3° in females); the lower face–throat angle by Legan and Burstone (100° ± 7°); and the "lip-chin-throat" angle by Worms et al. (110° ± 8°). This measurement is highly dependent on lip position relative to the chin, rather than on chin form.

### 3. Chin assessment within the submental region (throat length, chin-throat angle). Throat length or extension, measured in millimeters, does not necessarily project the relationship between chin and throat, although severely protruded or retruded chins may have an impact on chin/throat perception. The chin-throat angle, also known as the submental-cervical or cervico-mental angle (as opposed to the mento-cervical angle), has been reported at a low of 90° but also at 124°. A recent survey of this angle's attractiveness revealed an optimal value of 95°.

The chin-throat relationship requires proper analysis because of its variability. Indeed, a chin may be adequately extended in the anterior region yet be deficient in terms of harmony because of an increased chin-throat angle. The lack of consistent data in the literature, along with our clinical observation of an optimal intersection of the throat line with the mandible to define the chin-throat relationship, led us to formulate this hypothesis: a line tangent to the soft tissue border of the throat (T-line) bisects the body of the mandible in its middle in normal and well-balanced facial proportions.

Our aims were to (1) explore the association between chin projection and throat inclination in various malocclusions and through comparisons of before and after treatment in orthodontically and surgically treated subgroups and (2) determine the potential for the new T-line to assess the chin-throat connection.

### MATERIALS AND METHODS

This retrospective study was approved by the institutional review board of the American University of Beirut and included two samples of patients with malocclusion. The first sample comprised 135 pretreatment profile photographs of White adult patients, taken under controlled standardized conditions, and corresponding lateral cephalographs obtained in the same cephalostat (Instrumentarium Dental, Tuusula, Finland) in natural head position (Table 1). The inclusion criteria were the following: age between 18 and 50 years, no prior orthodontic treatment, and absence of craniofacial anomalies. Three groups of 45 patients each were defined as follows: Class I (ANB angle between 0° and 3°); Class II (ANB greater than 4.5°); and Class III (ANB less than 0°). Two subgroups (n = 25 each) were identified among the Class II and Class III patients who were treated with combined orthodontic/orthognathic intervention to compare their measurements before and after surgery.

The second sample consisted of 63 pre- and posttreatment lateral cephalographs of White patients (33 boys, 30 girls) with Class II, division 1 malocclusion who had been treated by growth modification with either a straight-pull headgear or a Frankel function regulator. The subjects were enrolled in a previously published randomized clinical trial in which the inclusion criteria were no prior orthodontic treatment, no craniofacial anomalies, minimum ANB angle of 4.5°, and minimum overjet of 5 mm. Their ages ranged between 7 and 13.3 years (average: 10.15 ± 1.45 years in boys, 9.32 ± 1.55 years in girls).

In the first sample, the lateral cephalograms and photographs were digitized, superimposed, and analyzed by one investigator using the Dolphin Imaging program, version 9 (La Jolla, Calif). In the second sample, only cephalograms were processed through the imaging program. The following lines and angles were traced (Figure 1): line "T," tangent to the throat.
RESULTS

The intraclass correlation coefficients ranged from 0.994 to 0.999 for all parameters, indicating high intraexaminer reliability.

Figure 1. Landmarks and lines used for linear and angular measurements. Go: soft tissue gonion, determined by superimposing hard tissue gonion on the photograph in Dolphin; Pog: soft tissue pogonion; throat line (T-line) tangent to the throat; MCA: mento-cervical angle at the intersection of the tangents to the upper contour and inferior border of the chin; CTA: chin-throat angle between T-line and submental plane; ANT/POST: anterior and posterior portions of the mandibular border determined by the intersection of T-line with Go-Pog line.

Table 2. Correlations Among the Different Variables in Malocclusion Groupsab

<table>
<thead>
<tr>
<th></th>
<th>ANT-MCA</th>
<th>McA-CTA</th>
<th>MCA-CTA</th>
</tr>
</thead>
<tbody>
<tr>
<td>r</td>
<td>P</td>
<td>r</td>
<td>P</td>
</tr>
<tr>
<td>All</td>
<td>-0.531</td>
<td>&lt;.0001**</td>
<td>-0.787</td>
</tr>
<tr>
<td>Class I</td>
<td>-0.159</td>
<td>.297</td>
<td>-0.828</td>
</tr>
<tr>
<td>Class II</td>
<td>-0.197</td>
<td>.195</td>
<td>-0.722</td>
</tr>
<tr>
<td>Class III</td>
<td>-0.435</td>
<td>.003**</td>
<td>-0.678</td>
</tr>
</tbody>
</table>

* ANT indicates anterior; MCA, mento-cervical angle; and CTA, chin-throat angle.
* Pearson product-moment correlation coefficient.
* Statistically significant at P < .05; ** Statistically significant at P < .01.

In the Class I group, the T-line bisected the mandibular soft tissue border nearly in its middle (ANT = 50.99%; POST = 49.01%; Table 1). ANT was comparatively reduced (36.01%) in Class II patients. Both MCA and CTA were wider in the Class II than the Class I and Class III groups, in which the findings were similar for angles MCA and CTA, and ANT and POST were almost equal. Comparison among malocclusion groups showed statistically significant differences in all measurements between Class II and both Class I (0.054 < P < .0001) and Class III (P < .001) groups, but only for MCA between Classes I and III (P = .016).

The highest correlation was found between ANT and CTA (r = −0.79) in all malocclusions in descending order from Class I to Class III (Table 2), as follows: Class I (r = −0.83); Class II (r = −0.72); and Class III (r = −0.68).

Comparisons between surgical and nonsurgical subgroups within the Class II and Class III groups revealed more severe sagittal discrepancy in the surgery subgroup: higher Class II (P = < .0001) and lower (Class III; P = .002) ANB (Table 3). None of the other measures were different in the Class III malocclusion, but the anterior sections were shorter and CTA greater among Class II surgical patients (P < .05).

In the surgically treated Class II and Class III patients, the within-group ANT differences before and after surgery were different in the Class II (P < .0001) but not in the Class III subgroup (Table 4). MCA decreased in both classes, the Class II angle moving farther away from Class I. CTA decreased in Class II but remained unchanged in Class III; in both malocclusions, the postsurgical results were within one standard deviation of the Class I values.

In the Class II surgical subgroup, the ANT and POST postsurgical measurements were no longer significantly different from those of the Class I group (P = .21) (Table 4, legend). The correlations between MCA and either ANT or CTA were higher after surgery than before surgery (Table 5). The correlations between ANT and CTA were high before and after surgery. In the Class III surgical subgroup, the nearly equal ANT
and POST before and after surgery (Table 4) were not different from those of the Class I group \( (P > .05) \). The correlations between ANT and MCA and between MCA and CTA increased from before to after surgery (Table 5). The correlations between ANT and CTA were high pre- and postsurgery. All correlations within the Class II and Class III subgroups were statistically significant \( (0.3 < P < .0001) \).

In the Class II, division 1 growing patients, ANT was nearly one-quarter (27.48%) of the mandibular distance before treatment, remarkably smaller than POST (72.52%). After treatment, ANT increased to nearly 40% (Table 6). CTA improved from 127° to 115° with treatment, ending with highly correlated ANT and CTA \( (r = -0.7) \).

**DISCUSSION**

This study introduced norms for chin-throat relation in various malocclusions and a simplified method by which to gauge this association. The chin-throat connection is critical in defining chin extension: an acute angle accentuates the perception of anterior projection, and a significantly obtuse angle conveys the impression of reduced extension. The latter is characteristic of aging, along with the development of a double chin, particularly if associated with weight gain.17

**T-Line**

The proposed tangent to the throat (T) bisected the mandibular border in its middle in acceptable esthetic appearance. When these proportions differed, facial esthetics were compromised and likely compatible with the existence of malocclusion. This premise was more evident in Class II malocclusions, in which the T-line intersected the mandibular border more anteriorly. The T-line/mandibular intersection was further validated by the results in treated adults and children. The proportions of ANT and POST also improved in the more deviant, surgical Class II dysmorphology, approximating the Class I norms accompanying more esthetically pleasing profiles. In the younger patients, the increase in ANT reflected ameliorated differential growth between the jaws and understandably did not reach the outcome achieved with surgery. It is noteworthy that at the time of treatment planning, the concept of T-line was not applied.

**Angular Measurements in the Chin-Throat Zone**

The average CTA in Class I subjects (116° ± 6.87°) was nearly midway between available norms (90° to 124°).10–14 Differences may be ascribed to the number of subjects in the studies or to gender or population characteristics. Another contribution of this study was determining pretreatment averages for CTA in Class II (132.13° ± 13.13°) and Class III (112.22° ± 13.11°) subjects, presumably defining zones of deviations from the Class I angulation. Class III CTA was closer to that observed in Class I patients. The Class II obtuse angle was less esthetic than either of the others, a conclusion

<table>
<thead>
<tr>
<th>Variable</th>
<th>Class I, Mean (SD)</th>
<th>Class II, Mean (SD)</th>
<th>Class III, Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Presurgical</td>
<td>Postsurgical</td>
<td>( P^a )</td>
</tr>
<tr>
<td>ANT, %</td>
<td>50.99 (5.16)</td>
<td>32.18 (7.14)</td>
<td>48.05 (10.89) ( &lt;.0001^a )</td>
</tr>
<tr>
<td>MCA, °</td>
<td>84.16 (9.4)</td>
<td>95.92 (10.12)</td>
<td>83.08 (18.94) ( .01^a )</td>
</tr>
<tr>
<td>CTA, °</td>
<td>116.11 (6.87)</td>
<td>137.28 (9.41)</td>
<td>120.88 (13.68) ( &lt;.0001^a )</td>
</tr>
</tbody>
</table>

\(^a\) ANT indicates anterior; MCA, mento-cervical angle; and CTA, chin-throat angle.

\(^b\) Independent \( t \)-test.

\(^c\) Paired \( t \)-test.

\(^*\) Statistically significant at \( P < .05 \); \(^**\) Statistically significant at \( P < .01 \).
Table 5. Correlations in the Class II and Class III Subgroups Among the Different Variables\textsuperscript{a,b}

<table>
<thead>
<tr>
<th></th>
<th>ANT-MCA</th>
<th>P-Value</th>
<th>ANT-CTA</th>
<th>P-Value</th>
<th>MCA-CTA</th>
<th>P-Value</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>r</td>
<td></td>
<td>r</td>
<td></td>
<td>r</td>
<td></td>
</tr>
<tr>
<td>Class II</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Presurgery</td>
<td>-0.516</td>
<td>.008**</td>
<td>-0.847</td>
<td>&lt;.0001</td>
<td>0.518</td>
<td>.008**</td>
</tr>
<tr>
<td>Post surgery</td>
<td>-0.643</td>
<td>.001**</td>
<td>-0.773</td>
<td>&lt;.0001</td>
<td>0.851</td>
<td>&lt;.0001**</td>
</tr>
<tr>
<td>Class III</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Presurgery</td>
<td>-0.587</td>
<td>.002**</td>
<td>-0.612</td>
<td>.001</td>
<td>0.428</td>
<td>.033*</td>
</tr>
<tr>
<td>Post surgery</td>
<td>-0.804</td>
<td>&lt;.0001**</td>
<td>-0.79</td>
<td>&lt;.0001</td>
<td>0.678</td>
<td>&lt;.0001**</td>
</tr>
</tbody>
</table>

\textsuperscript{a} ANT indicates anterior; MCA, mento-cervical angle; and CTA, chin-throat angle.
\textsuperscript{b} Pearson product-moment correlation coefficient.

This finding supports the concept of more geometric delineation (expansion) of hard and soft tissues as being more esthetic than the constriction of skeletal volume.\textsuperscript{18} The more obtuse CTA, and the fact that the T-line intersects the mandible more anteriorly in Class II malocclusion, represent a constitutional limitation to ideal correction of the chin-throat zone in this dysmorphology, barring the surgical correction, whereby, on average, the posttreatment CTA (reduced by more than 15°) was closer to the Class I readings. In the younger sample, CTA decreased after treatment (from 127° to 115°), also approximating the Class I values.

These observations indicate the possibility of using a workable soft tissue CTA value of ≤115° as “slightly unattractive,” the “very” and “extremely” unattractive set measured at 125° and 130°.\textsuperscript{14}

Measurements of the MCA in the Class I subjects (84.15° ± 9.4°) were close to the norms by Farkas\textsuperscript{a} (78.3° ± 7.9° in males; 83.9° ± 9.3° in females). MCA was greater in Class II (95.06° ± 10.9°) and slightly smaller in Class III (78.26° ± 9.36°) subjects, again demonstrating closer measures between Class I and Class III phenotypes relative to Class II phenotypes.

The correspondence of ANT and POST and CTA in Class I and Class III subjects reflects mandibular proportionality in Class III and supports the finding that most Class III malocclusions are associated with maxillary retrusion.\textsuperscript{19} Nevertheless, Classes I and III differed in MCA values (\(P = .016\)), this angle being smaller in Class III than in Class I malocclusions, indicating a relatively more prominent pogonion in Class III malocclusions. Further research should investigate differences in T-line and mandibular length between these malocclusions.

Clinical Significance and Implications

The chin-throat relationship, coupled with the position of the chin relative to the lips and nose, allows the practitioner to determine the chin extension in the facial profile, a critical step when the scope of therapeutic influence is only in the lower face. In contrast to the spectrum of linear and angular measurements of optimal chin-throat relationship, the T-line consistently divided the mandibular border into almost-equal parts in individuals with normal skeletal bases and closely approached this proportion in surgically corrected malocclusions. While directly related to the CTA (\(r = -0.79\); Table 2), as both include the throat line, the T-line further depicts the proportionality of the anterior extension of the chin. Indeed, a normal CTA may be found in a patient with deficient chin extension; an obtuse CTA may be noted with normal mandibular length yet with a deficient chin extension delineated through T-line; or an obtuse CTA may coexist with equal ANT and POST components of the mandibular border in the presence of a large mandible. Accord-
CHIN-THROAT ANATOMY: NORMAL RELATIONS AND CHANGES

The incorporation of T-line into orthodontic diagnosis

T-line and chin-throat angular measurements indicated

The hypothesis underlying this research was sup-

CONCLUSIONS

• The T-line is a practical tool for the evaluation of the

• The hypothesis underlying this research was sup-

• T-line and chin-throat angular measurements indi-

• The incorporation of T-line into orthodontic diagnosis

based on the harmony of adjacent facial structures

ACKNOWLEDGMENT

Dr Joseph G. Ghafari first introduced the throat line (T-line) at

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