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5 **What can anthropometric measurements tell us about the Mallampati classification?**

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9 Running title: Anthropometry and Mallampati classification

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14 All authors declare no conflict of interest.

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19 **Word count:** 1608

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21 **Abstract**

22 **Objectives:** Mallampati scoring is the most common examination method for predicting
23 possible intubation problems. The purpose of this study is to investigate the relationship of
24 facial anthropometric measurements with the modified Mallampati score (MMS).

25 **Methods:** Study population consisted of 153 male and 170 female volunteers (mean ages,
26 48,9±16,9 and 44,1±15,4 years, respectively). All participants subjected to Mallampati
27 scoring and facial anthropometric measurements during pre-operative visit. Anthropometric
28 measurements included inter-incisor gap, lower face height, thyrogonial length, thyromental
29 distance and bigonial distance. The relationship of anthropometric measurements with the
30 MMS was investigated by statistical analysis.

31 **Results:** Bigonial distance showed a positive correlation with the MMS ($r=0.857$; $p<0.001$),
32 whereas inter-incisor gap, lower face height, and thyromental distance showed negative
33 correlations ($r=-0.809$, $r=-0.738$, and $r=-0.762$ respectively $p<0.001$ for all). ROC and AUC
34 analysis showed that The BGD level had highest significant AUC ($p<0.001$). Optimal cut-off
35 point for BGD was >113 mm, and at this cut-off point, the sensitivity rate was 94.8% and the
36 specificity rate was 95.9%. BGD was the best predictor to discriminate MMS 3-4.

37 **Conclusion:** We suggest that facial measurements such as bigonial distance may be used as
38 alternatives for Mallampati evaluation when the patient's condition is not suitable for
39 Mallampati scoring.

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41 **Key words:** Anthropometry, Bigonial distance, Inter incisor gap, Modified Mallampati score,
42 Thyromental distance

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44 **Abstract word count:** 173

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46 **Introduction**

47 One of the most commonly reported cause of anesthesia related morbidity and mortality is the
48 failure of the anesthesiologist to maintain a patient's airway patency following the induction
49 of general anesthesia. The American Society of Anesthesiologists closed claims analysis of
50 adverse anesthetic outcomes reported that the most common cause of serious injury was due
51 to inadequate ventilation, esophageal intubation and difficult tracheal intubation (1). The
52 outcome was death or brain damage in 85% of these cases (1). Preoperative prediction of
53 difficult intubation in patients would obviously decrease the rate of anesthesia related adverse
54 respiratory events.

55 The Mallampati classification is a standard method for preoperatively predicting a
56 difficult endotracheal intubation. The original and modified Mallampati scorings are used as
57 preoperative bedside tests to predict a difficult airway. The Mallampati classification is
58 assigned according to the extent to which the base of tongue is able to block the visibility of
59 pharyngeal structures, including the soft palate, uvula, and faucial pillars into three classes.
60 Samssoon and Young (2) modified the original Mallampati classification system (3) to include
61 a fourth class, in which the soft palate, uvula and faucial pillars could not be visualized. In
62 "class IV," only the hard palate can be seen. A large inter-individual variation between
63 observers grading the Mallampati classification has previously been noted. This has been
64 hypothesized to be due to variation in clinical experience and exposure (4). Anthropometric
65 measurements can be an alternative to the Modified Mallampati classification which cannot
66 be performed on some patients.

67 Thyromental distance (TMD) and inter-incisor gap (IIG) were frequently used in
68 predicting difficult intubation, however, particularly in patients with cervical problems these
69 measurements were hard to evaluate. Although some anthropometric measurements have been
70 used in predicting difficult intubation, their relationship with the Modified Mallampati score
71 had not been investigated. We aimed to determine if certain facial anthropometric

72 measurements can be used as an alternative to the Modified Mallampati classification system
73 in patients in whom the classification could not be performed due to difficulties such as
74 cervical trauma and unconsciousness.

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98 **Methods**

99 ***Study population***

100 After approval of the Ethics Committee, written informed consents were obtained from 323
101 patients who accepted to participate in this study. Mallampati score distribution in general
102 population is not even. Class I and II are more frequent than Class III and IV, therefore,
103 patients were not selected randomly for anthropometric measurements in order to equalize to
104 number of patients in each Mallampati group. Exclusion criteria included inability to sit, gross
105 anatomical abnormality or recent surgery of the head and neck, patients with severe
106 cardiorespiratory disorders and patients younger than 18 years of age. Demographic data
107 including age, sex, weight, height, and body mass index (BMI) were also recorded.

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109 ***Mallampati classification***

110 The Modified Mallampati classification was made by an experienced anesthetist (AC)
111 according to Modified Mallampati Score (MMS) (3). Oropharyngeal view was assessed with
112 patient in sitting position and the tongue fully protruded but without phonation. It was rated
113 Class I if the soft palate, fauces, uvula and pillars were visible; Class II if soft palate, fauces
114 and uvula were visible, Class III if only the soft palate and base of the uvula were visible and
115 Class IV if the soft palate was not visible.

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117 ***Anthropometric measurements***

118 All anthropometric measurements were made by an anatomist (AY) who was blinded to
119 Mallampati status and score of the patients. The anthropometric measurements were made by
120 using caliper at the same time of each measurement day. All anthropometric measurements
121 were made in the seated, neutral position and head extended position (Figure 1). Inter-incisor
122 gap (**IIG**, Each patient was asked to open his/her mouth as wide as possible and the distance
123 between the upper and lower incisors at the midline was measured), lower face height (**LFH**,

124 The patient was seated with the head in neutral position. The straight distance from the
125 subnasale to the mentum was measured with caliper), thyro-gonial length (**TGL**, The patient
126 was seated with the head in neutral position. The straight distance from the angle of mandible
127 to the laryngea was measured with caliper), thyromental distance (**TMD**, The straight distance
128 from mentum to the laryngea was measured while the head was fully extended and the mouth
129 was closed), bigonial distance (**BGD**, The patient was seated with the head in neutral position.
130 The distance between the angle of mandible was measured with caliper) measurements were
131 recorded. Standard anthropometric landmarks were used for all measurements (5).

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133 *Statistical analysis*

134 Results are expressed as means (\pm SD) or numbers (percentage). Normality distribution of the
135 variables was tested using the one sample Kolmogorov-Smirnov test. Spearman correlation
136 analysis was used to examine the relationship of the modified Mallampati score and the five
137 anthropometric measurements. Categorical variables were compared by Chi-Square test.
138 Kruskal Wallis test was used for comparison of five anthropometric variables among the four
139 MMS subgroups, and then post-hoc Bonferroni test was used for pairwise comparisons.

140 Receiver operating characteristic (ROC) curve was used to calculate the area under
141 curve (AUC) and the predictive power of the variables for MMS (1,2 or 3,4) was assessed. A
142 plot of true positive rate against false positive rate was made and the AUC was measured. The
143 sensitivity and specificity rates of the variables were estimated by cut off points. The AUC is
144 a measure of the overall discriminatory power of the prognostic variable. A value of 1.0
145 indicates perfect discrimination, a value of 0.5 equals random prediction and a value of lower
146 than 0.5 indicates no discriminative power. A p value <0.05 was considered statistically
147 significant.

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150 **Results**

151 General characteristics of the study group were given by Mallampati subgroups in Table 1.
152 There were no significant differences between the Mallampati subgroups in terms of age,
153 gender distribution, and body mass index. Comparison of the mean anthropometric
154 measurements between the Mallampati subgroups were shown in Table 2. IIG, LFH, TMD,
155 and BGD values were significantly different among the four Mallampati subgroups. On the
156 other hand, TGL measurements showed similar results. An optimal decision threshold was
157 identified for the anthropometric measurements using a ROC (Receiver Operating
158 Characteristics) curve analysis. Cut-off values, predictive accuracies, area under the curves
159 (AUCs) are shown in Table 3. AUCs of predictor variables were ranged from 0.881 to 0.986.
160 The BGD level had highest significant AUC ($p < 0.001$). Optimal cut-off point for BGD was
161 >113 , and at this cut-off point, the sensitivity rate was 94.8% and the specificity rate was
162 95.9%. However, the LFH level had lowest significant AUC ($p < 0.001$). Optimal cut-off point
163 for LFH was ≤ 63 , and at this cut-off point, the sensitivity rate was 73.9% and the specificity
164 rate was 94.1%. BGD was the best predictor to discriminate MMS 3-4.

165 Spearman correlation coefficients between MMS and the IIG, LFH, TMD and BGD
166 levels are -0.809, -0.738, -0.762, and 0.857 respectively. Negative correlation coefficients
167 found between MMS and IIG, LFH, and TMD variables show that MMS increased while the
168 levels of these variables decreased. However BGD showed a positive correlation with MMS.

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174 **Discussion**

175 The novel and the main finding of this study was that bigonial distance (BGD) was the best
176 predictor to discriminate modified Mallampati scores (MMS) 3-4. Bigonial distance in other
177 words lower face width may show the curvature depth of palatoglossal arch. The larger the
178 bigonial distance, the more shallow the depth of palatoglossal arch, and thus the worse the
179 Mallampati score. We evaluated five different facial measurements namely, inter-incisor gap,
180 lower face height, thyrogonial length, thyromental distance and bigonial distance. Of these,
181 inter-incisor gap, lower face height and thyromental distance are measurements of sagittal
182 plan. On the other hand, thyrogonial length is an oblique measurement whereas bigonial
183 distance is transverse one. Previous studies usually used vertical measurements as an index of
184 difficult intubation (6, 7). Our study differs by several aspects from those previous studies.
185 First, we added a transverse measure i.e. bigonial distance. To the best of our knowledge, this
186 is the first study which included a transverse measure to predict Mallampati score. Second,
187 the previous studies focused on difficult intubation and correlated certain facial measures with
188 difficult intubation. In contrast, we correlated facial measures with Mallampati score rather
189 than difficult intubation. Although the relationship between Mallampati score and difficult
190 intubation is high, worse Mallampati score may not always indicate difficult intubation.

191 Mallampati classification requires opening of mouth which is vertical movement of
192 mandible. Therefore, many studies focused on vertical facial measurements such as
193 thyromental distance (6-9). Thyromental distance (TMD) is considered to be an indicator of
194 mandibular space. This test also reflects movement of the tongue (10). If TMD increases
195 thyroid cartilage and hyoid bone move away from the mandible, increases in these distances
196 may cause depression of the root of tongue which is attached to the hyoid bone with the
197 hyoglossus muscle (11, 12). As the root of tongue moves away from the uvula, the
198 oropharyngeal cavity may become more visible and the Modified Mallampati score may
199 decrease. TMD lower than 60 mm is one the best predictors of difficult laryngoscopy (13). In

200 parallel with these previous findings, Mallampati score IV patients had the mean TMD of 62
201 mm in our study. However, the sensitivity of TMD to predict worse Mallampati scores was
202 78.4% whereas the sensitivity of BGD was 94.4%.

203 Lower face height (LFH) is another vertical measure of face. We found that LFH <63
204 mm is predicting modified Mallampati III or IV. Nevertheless, the sensitivity of LFH was
205 only 73.9% which is the lowest sensitivity rate of the five measure that we used for the
206 purposes of this study.

207 There are several limitations of this study that deserve comment. First, one should be
208 careful when extrapolating our results to the practice of difficult intubation. Because, we did
209 not included intubation data due to technical difficulties. Therefore, all the patients in the
210 subgroup with Mallampati score 3 and 4 might not be experienced difficult intubation.
211 However, it has long been known that there is a strong correlation between Mallampati score
212 III – IV and difficult intubation (2, 14).

213 In conclusion, this is the first study which included a transverse facial measure namely
214 bigonial distance to correlate with Mallampati score. Bigonial distance (BGD) showed better
215 sensitivity and prediction than vertical and oblique measures to discriminate modified
216 Mallampati scores (MMS) III-IV. We suggest that it can be measured practically on patients
217 and can be used as an alternative to the Modified Mallampati classification in patients in
218 whom the classification could not be performed due to difficulties such as cervical trauma or
219 loss of consciousness.

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275 **Tables and figure legends**

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277 **Table 1.** Demographic data of all patients

	MMS 1	MMS 2	MMS 3	MMS 4	p
	(n=84)	(n=86)	(n=84)	(n=69)	
Age (yr)	44.57 (15.66)	46.81 (17.72)	46.35 (15.98)	48.20 (15.75)	0.584
Gender (M/F)	40/44	44/42	32/52	37/32	0.214
Height (cm)	168.27 (6.60)	168.69 (7.47)	166.06 (6.79)	168.43 (6.34)	0.051
Weight (kg)	75.90 (8.43)	78.62 (8.29)	76.07 (8.09)	77.84 (8.21)	0.091
BMI (kg.m-2)	26.84 (2.86)	27.67 (2.84)	27.63 (2.88)	27.50 (3.09)	0.211

278 Data are means (SD) or number of patients. **Abbreviations:** **MMS**, Modified Mallampati

279 Score; **M**, Male; **F**, Female; **BMI**, Body Mass Index.

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281 **Table 2.** Anthropometric measurements

	MMS 1	MMS 2	MMS 3	MMS 4	p
	(n=84)	(n=86)	(n=84)	(n=69)	
IIG, mm	59.08 (5.22)	55.94 (4.79)	45.23 (4.96)	41.55 (6.13)	<0.001
LFH, mm	73.64 (7.20)	73.39 (5.79)	62.90 (6.68)	53.42 (5.41)	<0.001
TGL, mm	116.27 (8.64)	117.07 (7.77)	115.67 (9.33)	114.13 (8.05)	0.185
TMD, mm	86.71 (8.77)	83.71 (6.70)	69.90 (8.14)	62.61 (9.53)	<0.001
BGD, mm	98.68 (10.37)	102.55 (6.72)	122.05 (7.15)	139.26 (5.48)	<0.001

282 **Abbreviations:** **MMS**, Modified Mallampati Score; **IIG**, inter-incisor gap; **LFH**, lower face
 283 height; **TGL**, thyro-gonial length; **TMD**, thyromental distance; **BGD**, bigonial distance.

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286 **Table 3.** Cut-off values, predictive accuracies and area under the curves to discriminate
 287 Modified Mallampati Score (1,2 vs 3,4)

	Cut-off				
	(mm)	Sensitivity (%)	Specificity (%)	AUC (95% CI)	p
IIG	≤50	85,6 (79,0- 90,8)	94,7 (90,2- 97,5)	0,974 (0,950-0,989)	<0.001
LFH	≤63	73,9 (66,1- 80,6)	94,1 (89,4- 97,1)	0,922 (0,887-0,949)	<0.001
TMD	≤73	78,4 (71,1- 84,7)	98,8 (95,8- 99,8)	0,946 (0,916-0,968)	<0.001
BGD	>113	94.8 (90,0- 97,7)	95.9 (91,7- 98,3)	0.986 (0.966-0.996)	<0.001

288 **Abbreviations:** **IIG**, inter-incisor gap; **LFH**, lower face height; **TMD**, thyromental distance;
 289 **BGD**, bigonial distance.

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293 **Figure legends**

294 **Figure 1.** Anterior (A) and lateral (B) view of facial measurements.

295 M: Mentum; S: Subnasale; AM: Angle of mandible; LP: Laryngeal prominence; Sn: Sternal

296 notch; LFH: Lower face height; TGL: Thyrogonial length; TMD: Thyromental distance;

297 BGD: Bigonial distance.

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