Anesthesiology 2007; 106:916–23

Submandible Angle in Nonobese Patients with Difficult Tracheal Intubation

Noriko Suzuki, M.D., Shiroh Isono, M.D.,† Teruhiko Ishikawa, M.D.,‡ Yuji Kitamura, M.D.,* Yujiro Takai, M.D.,§ Takashi Nishino, M.D.‖*

Background: **Although functional immobility of craniofacial structures during direct laryngoscopy may cause difficult tracheal intubation (DTI), there may be an unfavorable specific craniofacial feature for successful tracheal intubation. The aim of this study was to identify the specific craniofacial features associated with DTI.**

Methods: **Digital photographs of nonobese patients with DTI (23 males and 18 females) and age– and body mass index–matched patients with easy tracheal intubation (ETI) (16 males and 16 females) were taken and used for measurements of various craniofacial dimensions. Composite facial pictures of each patient group were constructed for visualization of differences of the craniofacial features.**

Results: **Mandible position angle was significantly smaller in DTI males than in male patients with ETI. Submandible angle was significantly larger in both male and female DTI patients than in patients with ETI. Logistic regression analysis revealed that the submandible angle was a significant and independent variable associated with DTI among the craniofacial dimensions for both sexes. The specific craniofacial features were visually more evident in the profile in than frontal composites.**

Conclusion: **Increased submandible angle characterizes craniofacial features of patients with DTI.**

DIFFICULTY or failure in tracheal intubation by direct laryngoscopy is a major and life-threatening complication during anesthesia induction and emergency resuscitation.[1,2] Identification of specific features differentiating patients with difficult tracheal intubation (DTI) from those with easy tracheal intubation (ETI) may increase our understanding of DTI pathogenesis.

Arrangements of craniofacial structures may dynamically change during direct laryngoscopy. Displacement of oropharyngeal soft tissue anterior to the oral airway through the submandible space is essential for securing airspace for direct vision of the vocal cords. Although functional immobility of the craniofacial structures during the procedure may cause DTI, there may be an unfavorable specific craniofacial feature for successful tracheal intubation. Accordingly, we compared craniofacial dimensions between DTI and ETI patients to identify the specific craniofacial features associated with DTI.

Recent advancement of a morphing computer technique enables construction of an "average" face, which potentially clarifies specific features common in a group of subjects.[3,4] Accordingly, another purpose of this study is to present "average" faces of both DTI and ETI patients for visual perception of specific craniofacial features of DTI patients.

Materials and Methods

Subjects

The study protocol was approved by our ethical committee (Graduate School of Medicine, Chiba University, Chiba, Japan), and written informed consent was obtained from each subject.

As a routine clinical practice at our institute (Department of Anesthesiology, Chiba University Hospital, Chiba, Japan), patients who presented DTI during direct laryngoscopy at induction of general anesthesia are invited for postoperative consultation to our difficult airway clinic for the purpose of informing them of the difficulty encountered during laryngoscopy and of airway reevaluation. The difficulty is determined and confirmed by experienced staff anesthesiologists when the Cormack and Lehane grade of the laryngeal view during direct laryngoscopy is 3 or 4 at application of external laryngeal pressure.[5] Our standard procedure for direct laryngoscopy in adults is the use of the Macintosh No. 3 blade under the sniffing position (approximately 8 cm head elevation with cushions). Between December 2001 and April 2005, 63 patients with difficult laryngoscopy were assessed in our difficult airway clinic. The modified Mallampati score,[6] thyromental distance, upper and lower incisor distance with maximum mouth opening, and neck movement were reassessed by investigators (N.S. and S.I.). The intubation difficulty score (IDS) developed by Adnet *et al.*[7] was calculated based on the report by our anesthesia staff. The IDS is a sum of the following seven parameters: the number of supplementary intubation attempts, the number of supplementary operators, the number of alternative intubation techniques used, the Cormack and Lehane grade minus 1, the lifting force applied during laryngoscopy, the necessity of applied external laryngeal pressure, and the position of the vocal cords at intubation. A score of 0 represents an ideal intubation. An IDS between 1 and 5 represents slight difficulty, and an IDS greater than 5 represents moderate to major difficulty in tracheal intubation. Exclusion criteria in this study were (1) emergency surgery, (2) age younger than 20 yr, (3) obesity (body mass index greater than 30 kg/m^2), (4) limited mouth opening (less than 30 mm), (5) limited neck extension, (6) use of full denture(s), (7) apparent craniofa-

* Staff Anesthesiologist, † Associate Professor, ‡ Assistant Professor, ‖ Professor, Department of Anesthesiology (B1), Graduate School of Medicine, Chiba University, Chiba, Japan. § Assistant Professor, Division of Respiratory Medicine, Department of Internal Medicine (Omori), School of Medicine, Faculty of Medicine Toho University, Tokyo, Japan.

Received from the Department of Anesthesiology (B1), Graduate School of Medicine, Chiba University. Submitted for publication August 10, 2006. Accepted for publication January 8, 2007. Supported by grant-in-aid No. 18390425 from the Ministry of Education, Culture, Sports, Science and Technology, Tokyo, Japan.

Address correspondence to Dr. Isono: Department of Anesthesiology (B1), Graduate School of Medicine, Chiba University, 1-8-1 Inohana-cho, Chuo-ku, Chiba, 260-8670, Japan. isonos-chiba@umin.ac.jp. Individual article reprints may be purchased through the Journal Web site, www.anesthesiology.org.

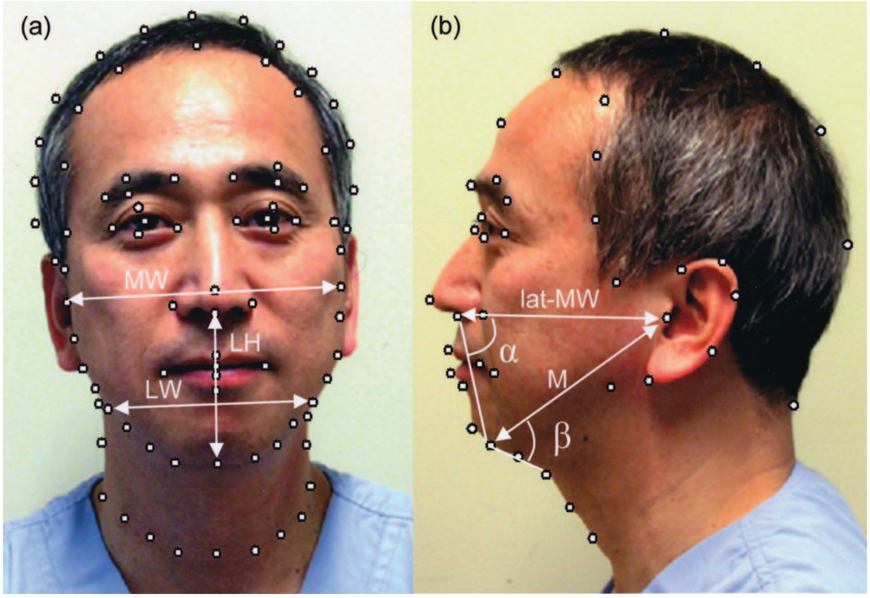

Fig. 1. Digital frontal (*A*) and lateral (*B*) photos with anatomical landmarks (84 anatomical landmarks for the frontal photo and 39 dots for the lateral photo) for measurements of craniofacial dimensions and construction of the "average" frontal face and profile. lat-MW (lateral middle face width) = distance between the tragus and columella of the nose; LH (lower face height) = distance between columella of the nose and the mentum; LW (lower face width) = distance between middle points of the mandibular contour; M (mandible length) = distance between the tragus and the mentum; MW (middle face width) = distance between the bilateral tragic; α (mandible position angle) = angle formed by the lat-MW and M lines; β (submandible angle) = angle formed by the M and submandible lines. The face is not blinded because it is one of the authors (S.I.).

cial abnormalities, (8) patients with rheumatoid arthritis, and (9) an IDS less than 5. These exclusion criteria were determined for clarification of nonfunctional craniofacial features in these patients. To minimize racial differences, subjects were limited to the Japanese.[8] Among the 63 patients with DTI, 23 male and 18 female patients met the criteria.

Thirty-two control subjects (16 males and 16 females) whose trachea was easily intubated were recruited during the period between December 2001 and April 2005 and selected to match the sex, age, weight, and height of the DTI patients. To facilitate potential differences between the groups, ETI was determined as a laryngeal view (Cormack and Lehane) of 1 or 2 without external laryngeal pressure and an IDS less than 5. The exclusion criteria above mentioned except No. 9 were also applied for the selection of control subjects.

Assessments of Craniofacial Features

To characterize craniofacial features, frontal and lateral digital photographs (COOLPIX4500; Nikon, Tokyo, Japan) of the neck, full face, and head of each subject at standing and looking straight ahead with the mouth closed were taken. Care was taken to adjust the height of the camera to eye level, whereas the distance between the camera and the subject was not standardized. Thirty-nine anatomical landmarks on each lateral photograph and 84 anatomical landmarks on each frontal photograph were determined as shown in figure 1 and used for both measurements of craniofacial dimensions and construction of an "average" face for each patient group. Lower face width and height relative to the middle face width were measured on the frontal photographs (fig. 1A). Mandible length relative to the lateral middle face width, mandible position angle, and submandible angle were measured on the lateral photographs (fig. 1B). An investigator (Y.K.) performed blind measurements of the craniofacial dimensions.

Construction of an "Average" Face

To visualize potential differences of the craniofacial features between DTI and ETI patients, an "average" craniofacial appearance for each patient group was constructed by composing digital photographs by matching anatomical landmarks defined in figure 1 between the photographs (N.S.). An "average" frontal face was constructed with use of computer programs developed by Harashima *et al.* (Face Tool; EEIC Engineering Department, University of Tokyo, Tokyo, Japan). A morphing computer program# was used for construction of an "average" profile. In theory, a morphing facial image on the coordinates U(x, y) is produced by composing two facial images on U1(x1, y1) and U2(x2, y2) to a composite proportion (t); $U(x, y) = (U1 - U2) * t + U2, 0 \leq t \leq 1$. An "average" face is obtained when $t = 0.5$, and therefore, an "average" face of two different patients consists of 50% facial property from each patient. Both color and shape of the faces were averaged in the morphing process. Repetitive production of the "average" face for pairs of patients produced an "average" face within each group of patients. Accordingly, the number of photos required for production of the group "average face" is 2^n in total; therefore, 16 was chosen as the maximum closest number within the total subject number of each group. Because our purpose was to clarify specific features of DTI patients, we produced an "exaggerated DTI face" by using photographs of eight DTI patients with extreme craniofacial variables determined by multiple regression analysis for each sex.

Morpher. Fujimiya's Computer Graphics Labo., Yokohama, Japan. Available at: http://www.asahi-net.or.jp/fx6m-fjmy/. Accessed December 23, 2006.

Table 1. Anthropometric and Craniofacial Variables of Male Patient Groups

	ETI Males (n = 16)	DTI Males (n = 23)	*P* Value
Age, yr	61 (58–63)	62 (53–68)	0.499
Height, cm	166 (163–169)	167 (165–171)	0.415
Weight, kg	65 (58–65)	62 (57–69)	0.782
Body mass index, kg/m^2	22.6 (21.3–24.6)	22.6 (20.2–24.1)	0.689
Mallampati score	2 (1–2)	3 (3–3)	<0.001
Thyromental distance, mm	90 (83–93)	70 (70–79)	<0.001
Mouth opening, mm	55 (43–55)	40 (40–50)	0.009
Cormack grade	1 (1–1)	3 (3–3)	<0.001
IDS score	0 (0–1)	10 (8–11)	<0.001
Lower face width, LW/MW	0.68 (0.64–0.70)	0.67 (0.65–0.69)	0.830
Lower face height, LH/MW	0.48 (0.45–0.51)	0.50 (0.47–0.54)	0.149
Mandible length, M/lat-MW	1.19 (1.15–1.26)	1.14 (1.10–1.20)	0.120
Mandible position angle, α, °	90.0 (85.0–94.5)	83.0 (80.0–90.3)	0.022
Submandible angle, β, °	58.5 (52.5–64.0)	69.0 (63.8–75.8)	<0.001

Definitions of the craniofacial dimensions are described in figure 1. Values are median (25th–75th percentile). *P* values were obtained by Mann–Whitney rank sum test.

DTI = difficult tracheal intubation; ETI = easy tracheal intubation; IDS = intubation difficulty scale reported by Adnet *et al.*[7]

Statistical Analyses

The Mann–Whitney rank sum test was used to assess differences of anthropometric and craniofacial variables between the groups. Spearman correlation analyses were performed between physical assessments for predicting difficult intubation such as the modified Mallampati score, thyromental distance, and mouth opening and craniofacial dimensions. Multiple logistic regression analysis was performed by using all craniofacial dimensions as independent variables and DTI as a positive response. A logistic regression model was produced with variables that had significant coefficients. $P < 0.05$ was considered to be significant. All variables were presented as median (25th–75th percentile).

Results

Anthropometric parameters, airway assessments, and laryngeal view during direct laryngoscopy and intubation difficulty score are presented for each patient group in table 1 (male) and table 2 (female). Body habitus did not differ between ETI and DTI groups, whereas higher Mallampati score, shorter thyromental distance, and reduced distance between upper and lower incisors were evident in DTI patients. Tracheal intubation was more difficult in the DTI group by definition.

Results of craniofacial dimension measurements are presented in tables 1 and 2. Lower face width was significantly narrower in DTI females than in ETI females. Mandible position angle was significantly smaller in male DTI males than in ETI males. Submandible angle was significantly larger in both male and female DTI patients than in ETI patients. Figures 2 and 3 present “average” faces, visualizing the results of the craniofacial dimension analyses. More receded mandible and increased submandible angle are evident in the profile composites of DTI patients (figs. 2D and 3D). The differences of facial appearance between DTI and ETI patients

Table 2. Anthropometric and Craniofacial Variables of Female Patient Groups

	ETI Females (n = 16)	DTI Females (n = 18)	*P* Value
Age, yr	58 (56–62)	55 (51–68)	0.641
Height, cm	155 (154–159)	155 (151–157)	0.255
Weight, kg	57 (52–62)	53 (49–58)	0.277
Body mass index, kg/m^2	22.6 (22.2–24.7)	22.0 (19.9–24.7)	0.458
Mallampati score	2 (1–2)	2 (2–3)	0.090
Thyromental distance, mm	80 (75–85)	60 (57–66)	<0.001
Mouth opening, mm	53 (48–55)	40 (37–48)	<0.001
Cormack grade	1 (1–2)	3 (3–3)	<0.001
IDS score	0 (0–1)	8 (6–9)	<0.001
Lower face width, LW/MW	0.68 (0.64–0.73)	0.64 (0.63–0.66)	0.015
Lower face height, LH/MW	0.48 (0.46–0.53)	0.47 (0.44–0.48)	0.109
Mandible length, M/lat-MW	1.19 (1.11–1.21)	1.16 (1.07–1.18)	0.255
Mandible position angle, α, °	88.0 (81.5–90.5)	81.5 (76.0–89.0)	0.070
Submandible angle, β, °	53.5 (48.0–64.0)	67.5 (57.0–77.0)	0.003

Definitions of the craniofacial dimensions are described in figure 1. Values are median (25th–75th percentile). *P* values were obtained by Mann–Whitney rank sum test.

DTI = difficult tracheal intubation; ETI = easy tracheal intubation; IDS = intubation difficulty scale reported by Adnet *et al.*[7]

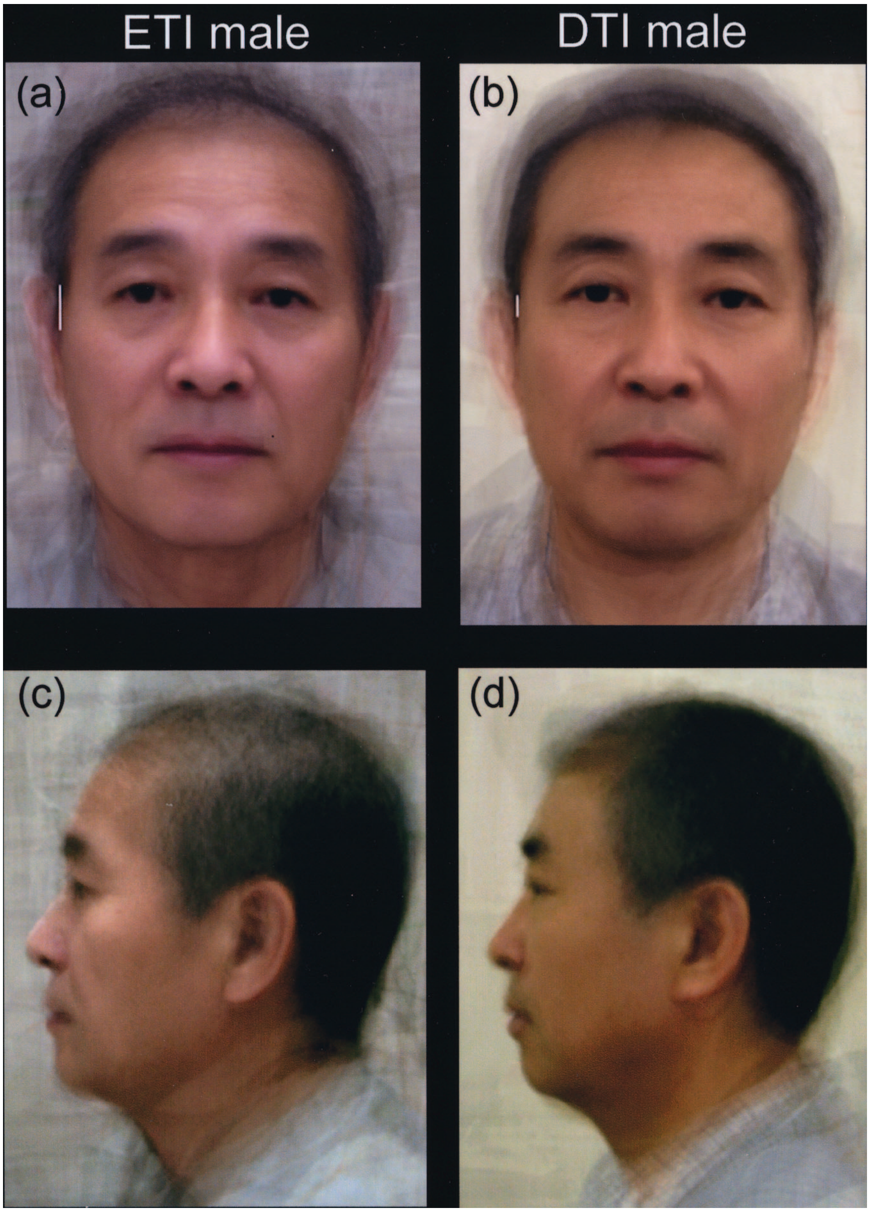

Fig. 2. "Average" frontal and lateral faces produced by averaging faces from 16 male patients with easy tracheal intubation (ETI) (*A* and *C*) and 16 patients with difficult tracheal intubation (DTI) (*B* and *D*). The faces are not blinded because they are "average" faces.

are more evident in the profile (figs. 2C, 2D, 3C, and 3D) than in frontal composites (figs. 2A, 2B, 3A, and 3B).

To determine the significant craniofacial variables associated with DTI, multiple logistic regression analysis was performed for each sex. We found that the submandible angle was a significant and independent variable associated with DTI among the craniofacial variables for both sexes (table 3). Based on this result, an "exaggerated DTI face" in which increased submandible angle were exaggerated was created for each sex by averaging faces from eight patients with greater submandible angle (fig. 4). Increased submandible angle was evident in both male (fig. 4A) and female (fig. 4B) "exaggerated DTI faces."

Table 4 presents results of correlation analyses between physical assessments for predicting difficult intubation and craniofacial dimensions. Mandibular position angle was indirectly associated with Mallampati score and directly associated with thyromental distance. Submandible angle was indirectly associated with thyromental distance in both sexes, whereas significant associations were observed between submandible angle and all DTI predictors in males.

Discussion

This is the first study, to our knowledge, of a systematic evaluation of facial appearance by use of digital photographs of patients with varying degrees of tracheal intubation difficulty. Patients with DTI were found to have a more receded mandible and increased submandible angle than age- and body mass index–matched patients with ETI. Logistic regression analysis indicated that increased submandible angle was significantly asso-

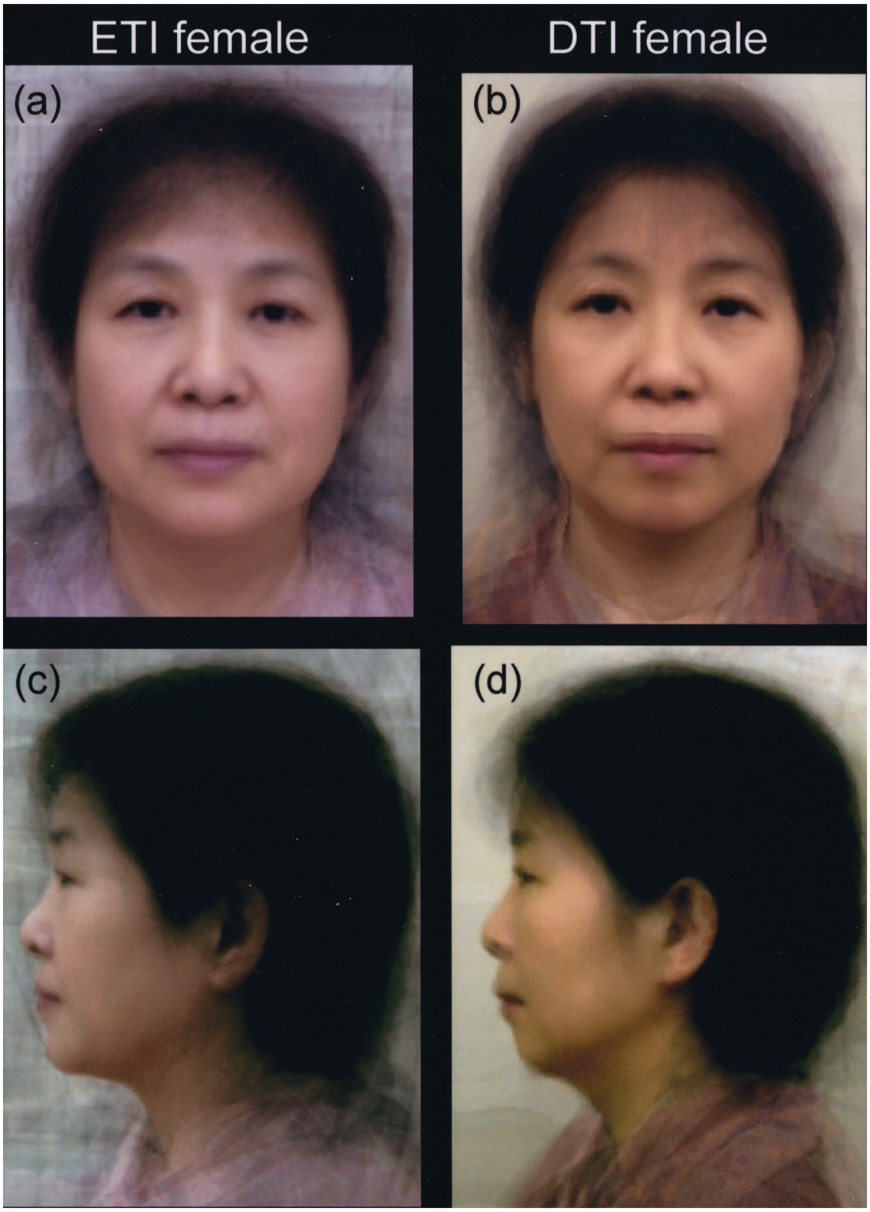

Fig. 3. "Average" frontal and lateral faces produced by averaging faces from 16 female patients with easy tracheal intubation (ETI) (*A* and *C*) and 16 female patients with difficult tracheal intubation (DTI) (*B* and *D*). The faces are not blinded because they are "average" faces.

ciated with DTI. Specific craniofacial features of DTI patients such as receded mandible and increased submandible angle were visually more evident in the profile than in the frontal composites.

Limitations of the Study

Our craniofacial assessment was two-dimensional and surface measurements without differentiating bony structures from soft tissue, both of which create facial appearance, whereas the direct laryngoscopy is a three-dimensional procedure in the three-dimensional structure with complicated interaction between bony and soft tissue structures. Despite the limitation, it was to our surprise that distinct differences in the plane profiles captured by a digital camera were found between DTI and ETI patients. Another limitation of this study is the absence of functional structural assessments while direct laryngoscopy is a dynamic functional procedure. Presence of limited mouth opening and neck movement may interact with increased submandible angle to further increase difficulty in tracheal intubation, a topic that necessitates further investigation, because these patients were excluded in this study. Finally, our subjects were nonobese Japanese, and results of this study may differ from those performed in whites and other races because

Table 3. Results of Multiple Logistic Regression Analysis

	Coefficient	SE	*P* Value
Model for males (n = 39)			
Constant	−10.005	3.492	0.004
Submandible angle, β	0.162	0.0549	0.003
Model for females (n = 34)			
Constant	−6.506	2.544	0.011
Submandible angle, β	0.109	0.0417	0.009

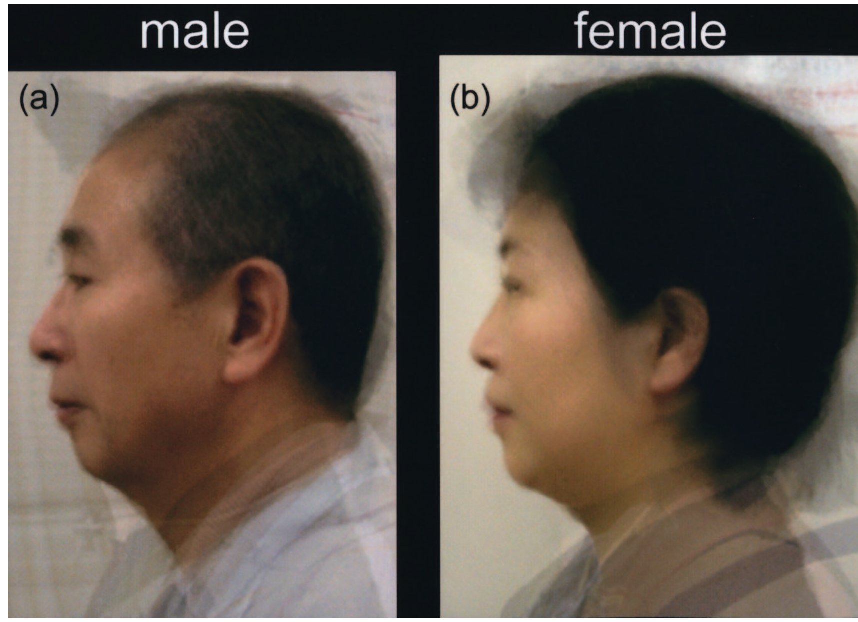

Fig. 4. A common "difficult tracheal intubation (DTI) face" for male (*A*) and female (*B*) created by averaging faces from eight DTI patients with greater submandible angle from each sex. The faces are not blinded because they are "average" faces.

obesity is more common in North America and Asians have a smaller and more receded mandible than whites.[8] Nevertheless, we believe that differences of the "average Japanese" face between patients with and without DTI provide clues to investigate mechanisms of DTI in any race, while control of the racial background is a necessity.

Potential Contributions of Increased Submandible Angle to DTI

Although our results clearly indicate increased submandible angle as a specific feature in DTI patients, a role of increased submandible angle in the mechanisms of DTI remains unclear. Submandible angle could be increased by either excessive submandible soft tissue or foreshortened mandible. While we only included nonobese patients in this study, increased submandible angle is a common feature of morbidly obese patients due to excessive submandible soft tissue. DTI in obese patients is controversial.[9–11] It should be noted that the highest reported prevalence of DTI in obese patients is 16%,[9] suggesting that tracheal intubation is easy in most obese patients with excessive submandible soft tissue. Accordingly, excessive submandible soft tissue alone may contribute little to the DTI mechanisms.

A single DTI predictor does not satisfactorily predict DTI, and a combination of DTI predictors increases DTI predictability,[12] suggesting that multiple factors may be involved in the DTI mechanisms. In fact, increased submandible angle was associated with various DTI predictors such as Mallampati score, interincisor distance, and thyromental distance (table 4), suggesting that the feature is a result of multiple contributing factors to DTI mechanisms. Accordingly, it is possible that DTI in patients with increased submandible angle results from difficulty in displacement of relatively excessive oropha-

Table 4. Results of Spearman Correlation Analyses between Craniofacial Dimensions and Physical Assessments for Predicting Difficult Intubation

	Mallampati Score	TMD	Mouth Opening
Males (n = 39)			
Lower face width, LW/MW	−0.021 (0.899)	0.045 (0.783)	0.010 (0.954)
Lower face height, LH/MW	0.150 (0.360)	0.046 (0.780)	0.011 (0.949)
Mandible length, M/lat-MW	−0.330 (0.040)	0.472 (0.003)	0.139 (0.404)
Mandible position angle, α, °	−0.339 (0.035)	0.462 (0.003)	0.196 (0.237)
Submandible angle, β, °	0.480 (0.002)	−0.580 (<0.001)	−0.421 (0.009)
Females (n = 34)			
Lower face width, LW/MW	−0.310 (0.074)	0.468 (0.006)	0.291 (0.100)
Lower face height, LH/MW	−0.244 (0.163)	0.447 (0.009)	0.263 (0.137)
Mandible length, M/lat-MW	−0.232 (0.185)	0.317 (0.072)	0.253 (0.155)
Mandible position angle, α, °	−0.401 (0.019)	0.402 (0.021)	0.238 (0.180)
Submandible angle, β, °	0.246 (0.160)	−0.379 (0.030)	−0.321 (0.068)

Definitions of the craniofacial dimensions are described in figure 1. Values are correlation coefficients (*P* values).

TMD = thyromental distance.

ryngeal soft tissue, particularly the tongue base, through narrow submandible space due to a foreshortened mandible. These speculations must be tested in the future studies by assessing dynamic structural movement during direct laryngoscopy.

Clinical Values of Facial Appearance for Predicting DTI

Although clinical significance of facial appearance for DTI prediction seems to be widely accepted by anesthesiologists, only a study performed by Wilson *et al.*,[13] to our knowledge, systematically evaluated it. Five risk factors, including weight, head and neck movement, jaw movement, receded mandible, and buck teeth, were identified in 75% of DTI patients with a cost of falsely identifying 12% of ETI patients. In accordance with their study, DTI patients in our study had a receded mandible, and our results further indicate a potential predictive value of increased submandible angle.

Difficult tracheal intubation may occur as a result of accumulation of mild to moderate difficulty during the tracheal intubation process, and the combination of Mallampati score and thyromental distance increased the positive predictive value.[12] Therefore, the addition of submandible angle assessment to the conventional predictors may improve DTI prediction, although submandible angle alone may not completely predict the multifactorial DTI events. Although DTI-predictive values of the submandible angle are currently uncertain, a large-scale, prospective, randomized, multicenter study must be performed in the future. Careful assessments of the profile are advantageous for identifying receded mandible and submandible angle in each preoperative patient.

An "Average" Face of DTI Patients

Although this is the first study presenting the "average" face of DTI patients using the morphing computer technique, an "average" face has been created for various groups of subjects, and its usefulness has been reported.[3,4] Certainly, the averaging process may decrease variation of color and shape when performed for a nonspecific general population. However, specific features would emerge on the "average" face when this technique is applied to a definite group of subjects. For example, likeness to the target face was better in an "average" face than in four different composites produced by eyewitnesses.[4] Interestingly, an "average" face of young females is more attractive than individual faces, and an "average" face produced by highly attractive females is more attractive than the "average young female face," indicating that averaging process would clarify phenotypes of our interest.[3] When there are specific features associated with DTI, variations of the DTI patient faces are possibly due to colors and dimensions unrelated to DTI, which are likely to be randomly distributed. Therefore, specific features would emerge on the average faces for the definite DTI group while decreasing the variations. In fact, increased submandible angle clearly emerged on the "average" DTI patient face, and it was more prominent in the "exaggerated DTI face."

Construction of the "average" DTI patient face may have several clinical significances. First, visualization of the specific profiles of DTI patients can correct emphatic images of DTI patient derived form wording such as "receded" or "increased" and decrease variability of DTI determinations based on facial appearance among anesthesiologists. Second, it may have an educational value for both paramedical staff as well as physicians who may encounter tracheal intubation.

Common Mechanisms of DTI and Difficult Mask Ventilation

Anatomical balance between the mandible size and soft tissue volume surrounding the pharyngeal airway seems to determine the airway size[14,15]; therefore, anatomical unbalance caused by either a small mandible or an increased amount of soft tissue is considered to result in development of obstructive sleep apnea (OSA). In fact, the small mandible is a feature of nonobese OSA patients,[16] and increased submandible soft tissue is reported to have value for predicting OSA.[17] Accordingly, the prominent facial features such as receded mandible with increased submandible angle in DTI patients coincide well with those in OSA patients. Assuming mask ventilation is more difficult in OSA patients than in non-OSA patients because of an abnormally collapsible pharyngeal airway[18]; the similarity of facial features suggests commonality of anatomical background and pathophysiology of DTI and difficult mask ventilation. In fact, DTI is common in OSA patients,[19] and difficult mask ventilation is often accompanied by DTI.[20]

In conclusion, increased submandible angle characterizes craniofacial features of patients with DTI. The specific feature of difficult tracheal intubation is more evident in the profile.

The authors thank Sara Shimizu, M.D. (Head of the Department of Plastic Surgery, JFE Kawatetsu Chiba Hospital, Chiba, Japan), who greatly helped to improve this manuscript.

References

1. Crosby ET, Cooper RM, Douglas MJ, Doyle DJ, Hung OR, Labrecque P, Muir H, Murphy MF, Preston RP, Rose DK, Roy L: The unanticipated difficult airway with recommendations for management. Can J Anaesth 1998; 45:757–76

2. Caplan RA, Posner KL, Ward RJ, Cheney FW: Adverse respiratory events in anesthesia: A closed claims analysis. ANESTHESIOLOGY 1990; 72:828–33

3. Perrett DI, May KA, Yoshikawa S: Facial shape and judgements of female attractiveness. Nature 1994; 368:239–42

4. Hasel LE, Wells GL: Catching the bad guy: Morphing composite faces helps. Law Hum Behav 2006; (Epub ahead of print)

5. Cormack RS, Lehane J: Difficult tracheal intubation in obstetrics. Anaesthesia 1984; 39:1105–11

6. Samsoon GLT, Young JRB: Difficult tracheal intubation: A retrospective study. Anaesthesia 1987; 42:487–90

7. Adnet F, Borron SW, Racine SX, Clemessy JL, Fournier JL, Plaisance P:

Lapandry: The intubation difficulty scale (IDS): Proposal and evaluation of a new score characterizing the complexity of endotracheal intubation. Anesthesiology 1997; 87:1290–7
8. Liu Y, Lowe AA, Zeng X, Fu M, Fleetham JA: Cephalometric comparisons between Chinese and Caucasian patients with obstructive sleep apnea. Am J Orthod Dentofacial Orthop 2000; 117:479–85
9. Juvin P, Lavaut E, Dupont H, Lefevre P, Demetriou M, Dumoulin JL, Desmonts JM: Difficult tracheal intubation is more common in obese than in lean patients. Anesth Analg 2003; 97:595–600
10. Brodsky JB, Lemmens HJ, Brock-Utne JG, Vierra M, Saidman LJ: Morbid obesity and tracheal intubation. Anesth Analg 2002; 94:732–6
11. Ezri T, Medalion B, Weisenberg M, Szmuk P, Warters RD, Charuzi I: Increased body mass index per se is not a predictor of difficult laryngoscopy. Can J Anaesth 2003; 50:179–83
12. Shiga T, Wajima Z, Inoue T, Sakamoto A: Predicting difficult intubation in apparently normal patients: A meta-analysis of bedside screening test performance. Anesthesiology 2005; 103:429–37
13. Wilson ME, Spiegelhalter D, Robertson JA, Lesser P: Predicting difficult intubation. Br J Anaesth 1988; 61:211–6
14. Isono S: Contribution of obesity and craniofacial abnormalities to pharyngeal collapsibility in patients with obstructive sleep apnea. Sleep Biol Rhythms 2004; 2:17–21
15. Watanabe T, Isono S, Tanaka A, Tanzawa H, Nishino T: Contribution of body habitus and craniofacial characteristics to segmental closing pressures of the passive pharynx in patients with sleep disordered breathing. Am J Respir Crit Care Med 2002; 165:260–5
16. Ferguson KA, Ono T, Lowe AA, Ryan CF, Fleetham JA: The relationship between obesity and craniofacial structure in obstructive sleep apnea. Chest 1995; 108:375–81
17. Tsai WH, Remmers JE, Brant R, Flemons WW, Davies J, Macarthur C: A decision rule for diagnostic testing in obstructive sleep apnea. Am J Respir Crit Care Med 2003; 167:1427–32
18. Isono S, Tanaka A, Ishikawa T, Tagaito Y, Nishino T: Sniffing position improves pharyngeal airway patency in anesthetized patients with obstructive sleep apnea. Anesthesiology 2005; 103:489–94
19. Siyam MA, Benhamou D: Difficult endotracheal intubation in patients with sleep apnea syndrome. Anesth Analg 2002; 95:1098–102
20. Langeron O, Masso E, Huraux C, Guggiari M, Bianchi A, Coriat P, Riou B: Prediction of difficult mask ventilation. Anesthesiology 2000; 92:1229–36