Mouth Opening

A New Angle

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Background: The authors hypothesized that cranio-cervical extension occurs during normal mouth opening.

Methods: Twenty volunteers were studied. Interdental distance was measured at four different degrees of cranio-cervical extension.

Results: Interdental distance increased from 28 mm (95% confidence interval, 25–30) in slight flexion to 46 mm (95% confidence interval, 42–49) at full extension. Nearly maximal mouth opening was obtained with 26° (95% confidence interval, 22–30) of cranio-cervical extension from neutral.

Conclusion: Cranio-cervical extension is an integral part of complete mouth opening in conscious subjects. Fixation of the cranio-cervical junction by disease, an internal or external fixation device, or technique may restrict mouth opening, with consequences for airway management.

MOUTH opening and cranio-cervical mobility have long been identified as crucial to successful airway management.1,2 Extension at the cranio-cervical junction is integral to basic airway maintenance maneuvers3 and direct laryngoscopy,4,5 and restricted mouth opening may make access to and control of the airway difficult. We have come to believe that cranio-cervical junction movement interacts with mouth opening and that restricted cranio-cervical mobility can result in reduced mouth opening ability.

Our interest was aroused by a surprising result in a study of direct laryngoscopy in patients with cervical spine disease.6 The Mallampati examination emerged as the best predictor of difficult direct laryngoscopy. At the same time, one of us (H. A. C.) noted that patients who had had cranio-cervical fixation surgery reported that yawning could be a painful experience. We hypothesized that opening the mouth wide involves cranio-cervical extension and that mouth opening is constrained in patients with reduced extension, resulting in a reduced oral aperture and hence poor Mallampati scores.

Materials and Methods

The study was approved by the local ethics committee (London, United Kingdom). Informed consent was obtained from 20 healthy adults. Subjects with any symptom or sign suggesting problems with mouth opening or neck movements were excluded. We excluded volunteers aged older than 45 years because mouth opening and neck extension are known to decrease with age.7,8 The subjects’ height, weight, and age were recorded. The subjects were asked to perform maximal mouth opening while their head was in four positions relative to their neck. Ideally, we would have liked to measure mouth opening and head position changes simultaneously and continuously, but we could not devise a methodology. Full flexion imposes a severe restraint on mouth opening, and we elected not to include that position. The four head/neck positions were (1) a position of slight flexion, in which a line joining the tragus of the ear and the canthus of the eye was horizontal; (2) the subject’s self-adopted neutral position; (3) the position adopted when the subject attempted maximal mouth opening without restraint on head position (we called this the “extension-allowed position”); and (4) full head extension. The cranio-cervical angles were measured by observing the angle formed between horizontal and the line joining the canthus of the eye and the tragus of the ear. A builder’s angle finder was used to measure the angles.9

In pilot studies, we had found that subjects unconsciously extend their heads on their necks when performing mouth opening. We devised a system, which minimized head movement during observations in the flexion and neutral positions. The subject wore a cycling helmet to which a laser pointer had been attached (fig. 1). The subject was seated in a chair so that the head was 1 m from a wall. The position of the laser beam on the wall was marked when the subject had adopted the flexion or neutral head/neck position, before the attempt at mouth opening was made. The mark on the wall was a piece of 1-cm square adhesive tape, which formed a target for the subject to aim the laser beam at. The subject kept the laser point on the target during mouth opening, which prevented him/her from extending further. The angle subtended by a vertical movement...
of the laser point of 1 cm at a distance of 1 m would be
half a degree, using the formula \( \tan^{-1}(a/b) \), where \( a \) is
the vertical distance and \( b \) is the horizontal distance. We
investigated the possibility that the subjects moved their
heads in an anteroposterior plane during mouth opening
in five of the volunteers, by observing the horizontal
displacement of the tragus. There was less than 1 cm of
movement during mouth opening in all of the positions.
The interdental distance between the upper and lower
incisors (IDD) was measured with a Willis bite gauge (SS
White Mfg., Gloucester, United Kingdom).

Statistical Methods

Power Calculation. A power calculation was per-
formed based on the results of a pilot study. Assuming an
SD in the differences in IDD of 5 mm, a sample size of 20
subjects gave us at least 90% power to detect a differ-
ence in means of 10 mm between the positions using a
paired \( t \) test with a 0.050 two-sided signi-
ficance level, allowing for multiple comparisons.
A retrospective power calculation confirmed that we
had included sufficient subjects in our study. This was
based on a one-way repeated-measures analysis of vari-
ance for the IDD scores, and assuming a mean IDD
variance of 500, an SD of 50 at each position, a be-
 tween-positions correlation of 0.05, and a significance level
of 5% indicates that a sample size of 19 will have 90%
power to detect a difference across the four IDD values.
Power calculations were made using nQuery Advisor
v3.0 (Statistical Solutions Ltd., Cork, Ireland).
A one-way analysis of variance was performed for
craniocevical angle measured at each of the four posi-
tions. Adjacent angles (flexion vs. neutral, neutral vs.
extension allowed, and extension allowed vs. full ex-
ension) were compared using paired \( t \) tests. A similar anal-
ysis was performed for IDD. Statistical analyses were
performed with Stata version 7.0 (StataCorp, College
Station, TX).

Demographics.

There were 10 men and 10 women in the study. The
median age was 32 yr (range, 24 - 43), and median height
was 171 cm (range, 162–181). The median value of
weight was 67 kg (range, 57–110), and the median body
mass index was 23.5 (range, 19 - 40).

Results

The mean IDD increased by a total of 18 mm between
the flexion and full extension positions. A one-way anal-
ysis of variance of IDD values demonstrated a statistically
significant difference between the IDDs (\( P < 0.0001 \)).
The IDDs measured at each position were significantly
different from one another at the 5% significance level
(\( P = 0.0004, P < 0.0001, P = 0.0028 \) for flexion vs. neutral, neutral vs.
extension allowed, extension allowed vs. full extension, respectively). The
craniocevical angles (CCAs) in the four positions were all significantly differ-
ent from one another (\( P < 0.0001 \)). Comparisons were made using the paired
\( t \) test.

Table 1. Craniocervical Position, Mean Craniocervical Angle,
and Mean IDD

<table>
<thead>
<tr>
<th>Position</th>
<th>CCA, ° (95% CI)</th>
<th>IDD, mm (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexion</td>
<td>0 (95% CI)</td>
<td>28 (25, 30)</td>
</tr>
<tr>
<td>Neutral</td>
<td>18 (16, 21)</td>
<td>34 (29, 37)</td>
</tr>
<tr>
<td>Extension allowed</td>
<td>44 (40, 48)</td>
<td>44 (40, 47)</td>
</tr>
<tr>
<td>Full extension</td>
<td>73 (69, 79)</td>
<td>46 (42, 49)</td>
</tr>
</tbody>
</table>

The interdental distances (IDDs) are all significantly different from one another
(\( P = 0.0004, P < 0.0001, P = 0.0028 \) for flexion vs. neutral, neutral vs.
extension allowed, extension allowed vs. full extension, respectively). The
craniocevical angles (CCAs) in the four positions were all significantly differ-
ent from one another (\( P < 0.0001 \)). Comparisons were made using the paired
\( t \) test.

CI = confidence interval.

Table 2. Changes in Mean Craniocervical Angle and Mean IDD
between Positions

<table>
<thead>
<tr>
<th>Change in Position</th>
<th>CCA, ° (95% CI) [% of Total Change]</th>
<th>IDD, mm (95% CI) [% of Total Change]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexion to neutral</td>
<td>18 (16, 21) [25]</td>
<td>6 (3.8) [33]</td>
</tr>
<tr>
<td>Neutral to extension</td>
<td>26 (22, 30) [36]</td>
<td>10 (8.13) [56]</td>
</tr>
<tr>
<td>Extension allowed to full</td>
<td>29 (25, 33) [40]</td>
<td>2 (1.4) [11]</td>
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</table>

Fifty-six percent of the total increase in interdental distance (IDD) occurred
between the neutral and extension-allowed positions.

CCA = craniocervical angle; CI = confidence interval.
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Discussion

Our results support the hypothesis that mouth opening and craniocervical flexion/extension are related. All
the subjects extended from neutral when asked to open
their mouths without restraint on head position (mean
of 26° [95% confidence interval, 21–30°]). This increase
in extension was only 36% of the total increase in craniocervical angle but allowed more than half (56%) of the
total increase in IDD between the flexion and full exten-
sion positions. We call this angle the “gape-facilitating
angle.” When craniocervical extension beyond the neu-
tral position was prevented, the subjects’ mean IDD was
12 mm less than their mean at full extension (26% of the
mean maximal IDD).

We do not know why mouth opening diminishes at
angles of neck extension below the gape-facilitating an-
gle, but limitation of mandibular excursion by compres-
sion of soft tissue behind the mandible probably plays a
part. In addition, the muscles responsible for active
mouth opening (lateral pterygoids, digastrics, geniohy-
roids, and mylohyoids) may be working at reduced
advantage when the neck is flexed. It is therefore pos-
sible that the reduction in IDD we observed would not be
countered in an anesthetized patient whose mouth was
actively opened by an anesthesiologist. We cannot
therefore state with confidence what significance our
findings have for airway management until suitable in-
vestigations have been conducted in anesthetized pa-
tients. Nevertheless, our study suggests that airway man-
gement in patients with craniocervical rigidity (caused
for example by disease, fixation devices, or manual sta-
bilization) may be adversely affected by not only the
disadvantages inherent in craniocervical rigidity, but also
those of reduced mouth opening consequent on the

An association between cervical spine disease and lim-
itation of mouth opening has been reported previous-
ly, but these reports suggested that the limitation of
mouth opening was due to an association between cer-
vical spine disease and temporomandibular joint disease,
rather than any effect of cervical spine mobility.

In conclusion, we report a mechanism involved in
normal mouth opening, which has not to our knowledge
been described previously. Mandibular movement and
craniocervical movement are interrelated. Humans
achieve full mouth opening by extending approximately
26° from the neutral position. Patients with restricted
craniocervical movement may have reduced mouth
opening ability. This phenomenon may contribute to the
difficulties with airway management that can occur in
patients with reduced craniocervical extension.

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