Effects of Intermaxillary Fixation During Orthognathic Surgery on Respiratory Function After General Anesthesia

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I examined the relationship between preoperative breathing route (nasal and/or oral) and respiratory status in 29 patients who underwent orthognathic surgery and intermaxillary fixation (IMF) with general anesthesia and in 14 healthy, adult control volunteers who received IMF without surgery or anesthesia. The tidal volume (V_T), minute respiratory volume (MV), respiratory rate, and end-tidal carbon dioxide concentration were measured for both nasal and oral breathing before and after IMF. Pulse oximetry recordings were also taken. There was no significant effect of IMF on any parameter in the volunteers. Fifteen patients engaged in nasal breathing only both before and after surgery with IMF (group pN), and 7 patients had combined nasal and oral breathing before but only nasal breathing after IMF (group pNO). V_T and MV decreased (536–357 mL and 7.84–5.40 L, respectively) in group pNO after IMF. These results suggest that assessment of the preoperative breathing status is helpful in predicting postoperative respiratory function after IMF and indicate that patients with preoperative mouth breathing require greater respiratory care after general anesthesia with IMF.

Key Words: General anesthesia; Intermaxillary fixation; Orthognathic surgery; Respiration.

Intermaxillary fixation (IMF) is often applied during orthognathic surgery to stabilize the occlusal position. Since IMF can compromise the upper airway, it may affect the patient's respiratory status. Some patients with maxillary deformities that require orthognathic surgery are inclined to keep their mouth open because of malalignment and malocclusion, and oral breathing is commonly observed. In such patients, IMF can interfere with the upper airway and adversely influence ventilation after surgery under general anesthesia. There is little specific information, however, on the correlation between preoperative breathing status and respiratory function after surgery with IMF under general anesthesia. In this study, I examined the relationship between the preoperative breathing route and the post–general anesthesia respiratory status in patients who underwent IMF during orthognathic surgery.

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METHODS

Before the study, a device for measuring respiration was prepared by fixing a partition in the center of a commercially available anesthesia mask (Clear Mask, Senko Ika Co, Tokyo, Japan) to separate the nasal and oral air streams. Air ingress through the nose and mouth was completely divided, without leakage, by tightly sealing the mask partition to the maxillary gingiva and upper lip (Figure 1). A respiratory monitor (Capnomac Ultima, Datex, Helsinki, Finland) was connected to the nasal and oral breathing conduits of the mask. The tidal volume (V_T), minute respiratory volume (MV), respiratory

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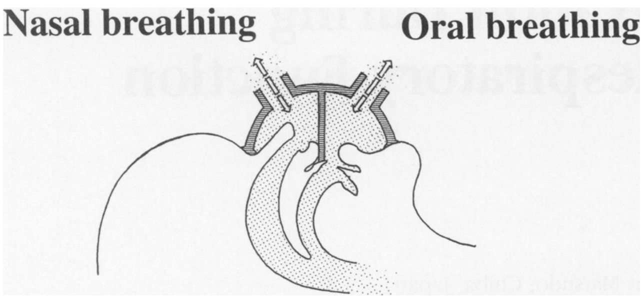

Figure 1. Mask for measuring respiration separately through the nasal and oral breathing routes.

rate (RR), and end-tidal carbon dioxide concentration ($EtCO_2$) were measured for each respiratory route. Oxygen saturation (SpO_2) was measured by fitting a probe for SpO_2 measurement to one of the subject's fingers. When both nasal and oral respiration was observed, the $EtCO_2$ measurement was taken from the breathing route with the larger respiratory volume. To obtain the measured value of each item, recorded data were entered into a computer at 10-second intervals, and the average of 6 points (1 minute) was calculated.

Fourteen healthy adult volunteers serving as controls were studied to assess normal respiratory function, and 29 oral surgery patients scheduled to undergo general anesthesia for orthognathic surgery involving IMF constituted the treatment group. This study was approved by the Ethical Committee of the Nihon University School of Dentistry at Matsudo, and all subjects were given informed consent forms according to the ethical guidelines of the 1975 Declaration of Helsinki.

In the control group, for measurement before IMF, each subject reclined in the supine position. A respiratory measurement mask was fitted, with the mouth slightly open (about 5 mm). The measurements of respiratory function described previously were then obtained. Intermaxillary fixation was performed by bilateral wire ligation of the first upper and lower premolars, and the respiratory measurements were retaken.

In the patient group, measurements were taken on the day before surgery in the same manner as described for the control group. After the patient awakened from the general anesthesia used during surgery with IMF, complete recovery of spontaneous respiration was confirmed. The patient then underwent extubation and was kept quiet under room air inhalation. Respiratory measurements were then taken using the special mask.

For general anesthesia, all patients were premedicated intramuscularly with atropine sulfate (0.5 mg) and midazolam (0.05 mg/kg) 15 minutes before induction of anesthesia. Each patient was induced with sodium thiopental (5 mg/kg), paralyzed with vecuronium bromide (0.1 mg/kg), and intubated nasally. Anesthesia was maintained with 66% nitrous oxide and 1.0–1.5% sevoflurane in oxygen. On completion of surgery, muscle relaxation was reversed with neostigmine (1 mg) and atropine sulfate (0.5 mg).

The mean and SD for each measurement parameter were calculated for each treatment group and testing period. Statistical analyses were carried out using Student's t test at a 95% confidence level for significance.

RESULTS

The volunteer subjects were divided into 2 groups: 7 subjects who showed only nasal breathing before and after IMF (group cN) and 7 subjects who exhibited both nasal and oral breathing before IMF but only nasal breathing after IMF (group cNO). There was no significant difference between the 2 test groups in background factors such as age, height, and body weight (Table 1).

Measurements of V_T and MV before and after IMF for each group are shown in Figure 2. Both V_T and MT increased slightly but not significantly after IMF in group cN. There was no significant change in the RR, $EtCO_2$, or SpO_2 (Table 2). Similarly, no significant change was observed in any of the measured parameters in group cNO.

The test subjects included 15 patients who engaged

Table 1. Demographic Data*

	Control Groups		*Patient Groups*	
	Group cN	*Group cNO*	*Group pN*	*Group pNO*
Sex, M/F	7/0	7/0	2/13	2/5
Age, y	24.6 ± 3.5	23.9 ± 1.6	24.3 ± 5.2	26.9 ± 7.4
Height, cm	171 ± 6	169 ± 5	160 ± 8	162 ± 7
Weight, kg	70 ± 14	71 ± 11	55 ± 101	58 ± 12
Operation time, min	...	...	132 ± 54	153 ± 63
Anesthesia time, min	...	...	188 ± 36	211 ± 65

* Group cN indicates patients who showed only nasal breathing before and after intermaxillary fixation (IMF); group cNO, patients who showed both nasal and oral breathing before IMF but only nasal breathing after IMF; group pN, patients engaged in nasal breathing only both before and after IMF; and group pNO, patients who showed nasal and oral breathing before but only nasal breathing after IMF. Values are expressed as mean ± SD.

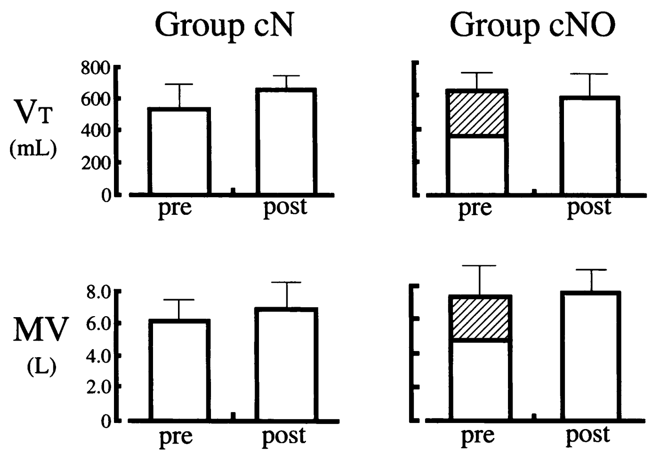

Figure 2. Tidal volume (V_T) and minute respiratory volume (MV) values in groups cN (subjects who showed only nasal breathing before and after intermaxillary fixation) and cNO (subjects who exhibited both nasal and oral breathing before IMF but only nasal breathing after intermaxillary fixation). Pre indicates pre–intermaxillary fixation; post, post–intermaxillary fixation; open bars, nasal breathing; hatched bars, oral breathing; and vertical lines, SDs. In group cNO, only nasal breathing was observed after intermaxillary fixation, but it had no significant effect on respiration.

in nasal breathing only both before and after surgery with IMF (group pN), 7 patients with nasal and oral breathing before surgery but only nasal breathing afterward (group pNO), and 7 patients with 6 different breathing patterns (Table 3). Because of the limited number of patients in most breathing categories, only groups pN and pNO were compared statistically.

There was no difference in background factors between groups pN and pNO (Table 1). In group pN, V_T and MV tended to decrease after surgery with IMF, but no significant difference was observed (Figure 3). The RR, $EtCO_2$, and SpO_2 were unchanged after IMF (Table 4).

In group pNO, V_T before IMF was 282 ± 91 mL for nasal breathing and 254 ± 99 mL for oral breathing, making a total of 536 ± 159 mL (Figure 3). After IMF, breathing was only through the nasal route. The nasal V_T increased, and the total V_T therefore decreased to 357 ± 89 mL. The MV before IMF was 4.49 ± 1.27 L for nasal breathing and 3.35 ± 1.56 L for oral breathing, making a total of 7.84 ± 2.35 L. After IMF, the total MV decreased significantly to 5.40 ± 1.65 L. In addition, IMF had no significant effect on RR or SpO_2; however, the $EtCO_2$ increased significantly after IMF (Table 4).

Table 2. Respiratory Values in the Control Groups*

	Group cN		*Group cNO*	
	Pre-IMF	*Post-IMF*	*Pre-IMF*	*Post-IMF*
RR, beats/min	13 ± 3	13 ± 3	13 ± 2	14 ± 3
$EtCO_2$, mm Hg	37 ± 2	40 ± 2	38 ± 2	41 ± 2
SpO_2, %	97 ± 1	97 ± 1	97 ± 1	97 ± 1

* Group cN indicates patients who showed only nasal breathing before and after intermaxillary fixation; group cNO, patients who showed both nasal and oral breathing before intermaxillary fixation but only nasal breathing after intermaxillary fixation; Pre-IMF, pre–intermaxillary fixation; post-IMF, post–intermaxillary fixation; RR, respiratory rate; $EtCO_2$, end-tidal carbon dioxide tension; and SpO_2, pulse oximetry. Values are shown as mean ± SD.

Table 3. Patient Distribution by Breathing Route Categories*

Breathing Routes			
Pre-IMF	→	*Post-IMF*	*No. of Patients*
Nasal	→	Nasal	15 (group pN)
Nasal and oral	→	Nasal	7 (group pNO)
Nasal	→	Nasal and oral	3
Nasal and oral	→	Oral	1
Nasal	→	Oral	1
Oral	→	Nasal	1
Nasal and oral	→	Nasal and oral	1

* Pre-IMF indicates pre–intermaxillary fixation; post-IMF, post–intermaxillary fixation; group pN, patients engaged in nasal breathing only both before and after intermaxillary fixation; and group pNO, patients who showed nasal and oral breathing before but only nasal breathing after intermaxillary fixation.

DISCUSSION

There are several ways to measure separately nasal and oral breathing. For example, the flow rates of nasal and

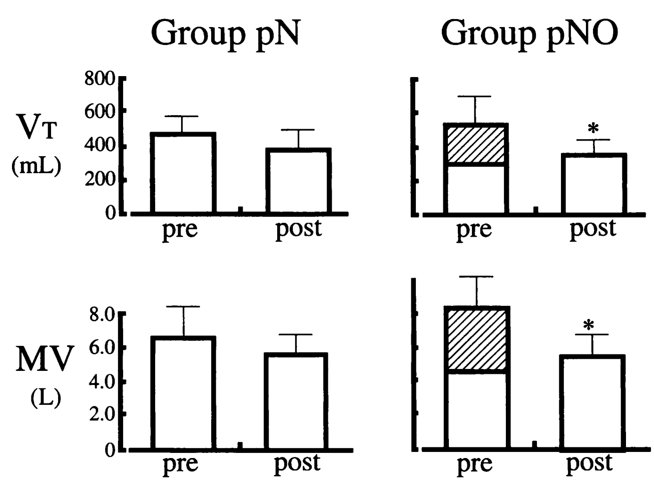

Figure 3. Tidal volume (V_T) and minute respiratory volume (MV) values in groups pN (subjects engaged in nasal breathing only both before and after surgery with intermaxillary fixation) and pNO (subjects who showed combined nasal and oral breathing before but only nasal breathing after intermaxillary fixation). Pre indicates pre–intermaxillary fixation; post, post–intermaxillary fixation; open bars, nasal breathing; hatched bars, oral breathing; and vertical lines, SDs. *$P < .05$ compared with total pre value.

Table 4. Respiratory Values in the Patient Groups†

	Group pN		Group pNO	
	Pre-IMF	Post-IMF	Pre-IMF	Post-IMF
RR, beats/min	14 ± 3	15 ± 4	16 ± 6	16 ± 3
$EtCO_2$, mm Hg	39 ± 3	37 ± 4	34 ± 2	40 ± 2*
SpO_2, %	98 ± 1	97 ± 1	97 ± 1	97 ± 1

† Group pN indicates patients engaged in nasal breathing only before and after intermaxillary fixation; group pNO, patients who showed nasal and oral breathing before but only nasal breathing after intermaxillary fixation; Pre-IMF, pre–intermaxillary fixation; post-IMF, post–intermaxillary fixation; RR, respiratory rate; $EtCO_2$, end-tidal carbon dioxide tension; and SpO_2, pulse oximetry. Values are shown as mean ± SD.

* $P < .05$, compared with pre-IMF value.

oral breathing can be determined individually using "flow-nasality graphy."[1] Alternatively, thoracic movement can be measured using head-out body plethysmography to calculate the total respiratory volume and a nasal mask to determine the nasal respiratory volume,[2] or inductive body plethysmography can be used.[3] In this study, the nasal and oral breathing routes were divided with a modified mask for anesthesia and separately connected to a respiration monitor to measure each breathing route. This method allows the noninvasive quantification of the respiratory contributions by each breathing route.

All but 2 of the 43 subjects enrolled in this study engaged in nasal breathing after IMF. The main reason for this may be that IMF reduced the dental space and increased oral airway resistance.[4] In patients, the oral cavity may be further reduced by swelling of the tongue and oral soft tissue after surgical procedures[5] and by retraction of the root and elevation of the back of the tongue.[6,7] These factors may have increased oral respiratory resistance and forced nasal breathing in most patients in this study. Conversely, the patients with postoperative oral breathing may have experienced increased nasal resistance because of swelling of the nasal mucosa induced by irritation associated with nasoendotracheal intubation[8] or the presence of nasogastric tubes. In the future, it will be necessary to measure the airway resistances of the nasal and oral routes.

The data in this study showed no change in the respiratory volume before and after IMF in group pN, which agrees with a report by Sasao et al,[9] who mentioned that respiratory volumes were not reduced in patients 30 years and younger after orthognathic surgery. However, V_T and MV decreased in group pNO because of the disappearance of oral breathing. Sasao et al[9] did not examine the influence of IMF or preoperative breathing routes. Thus, their study cannot exclude the possibility that the preoperative breathing route may predict changes in postoperative respiratory volumes after IMF.

In the volunteers with partial oral breathing before IMF (group cNO), both V_T and MV were undiminished after IMF. Nishino and Kochi[10] reported that the nasal-oral converting mechanism of respiration is suppressed under thiopental-induced sedation and that consciousness is important for converting oral breathing to nasal breathing. Therefore, the converting mechanism of nasal-oral respiration may be suppressed immediately after general anesthesia, when the effects of the anesthetic agents probably still remain, and nasal breathing may not compensate for the decreased respiratory volume caused by the cessation of oral breathing. This conclusion is weakened somewhat by the fact that the volunteers were all male, whereas most of the patients were female (Table 1). It may be possible that sex differences account for the disparity in results between the control and patient subjects.

In this study, there was no change in SpO_2 after IMF. Kitagawa et al[11] reported that the incidence of decreased SpO_2 was low in patients who underwent IMF during surgery because they were young and rarely had risk factors for decreased SpO_2. The subjects of this study displayed the same characteristics.

The reason for an increased $EtCO_2$ in group pNO after IMF may be that the measured preoperative value was low. In these patients an increased dead space associated with breathing through both the nose and mouth simultaneously may have diluted the expired carbon dioxide more than when the nasal route was used alone after IMF.

Intermaxillary fixation can promote severe complications such as airway occlusion,[12] aspiration pneumonia, and atelectasis because it interferes with the discharge of vomitus.[13] In addition, IMF may artificially narrow the airway and impair respiratory function. The results of this study suggest that identification of the preoperative breathing route is necessary for assessing respiratory function after orthognathic surgery with IMF under general anesthesia. In particular, patients associated with preoperative oral breathing may require greater respiratory care after general anesthesia for orthodontic surgery that includes IMF.

CONCLUSIONS

In control subjects, oral respiration disappeared after IMF, and all subjects engaged in pure nasal breathing. Increased nasal respiration compensated for the loss of oral breathing. Of the 29 patients enrolled in the study, 27 (93%) breathed mainly or solely through the nose after IMF. However, nasal breathing after IMF did not increase sufficiently to offset the loss of oral breathing in patients with preoperative oral and nasal breathing, decreases occurred in V_T and MV, and the $EtCO_2$ was elevated. These results suggest that altered consciousness may influence these values after surgery and IMF. In patients with concomitant preoperative oral breathing, great respiratory care is necessary after general anesthesia for orthodontic surgery that includes IMF. In cases where nasal breathing may be suppressed, the use of IMF during surgery requires careful consideration.

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