Three Monosyllables for Standard Words in Nasometer Test: To Evaluate Air Leakage in Maxillectomy Patients

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Clinical significance
Air leakage is a serious problem in maxillectomy patients. In this article, we propose an easy evaluation method using a Nasometer to achieve efficiency of treatment with several monosyllabic test words. This method can clearly determine the level of air leakage without limitations due to language or ability to read.

Abstract
Purpose: The purpose of this study was to establish an evaluation method using a Nasometer, with several monosyllabic test words, to reveal the level of air leakage in maxillectomy patients without limitations due to language or ability to read.

Methods: 20 normal Japanese (Group 1) and 20 international adults (Group 2), were asked to read 7 monosyllables, (5 vowels and 2 combined vowels, /a/, /i/, /u/, /e/, /o/, /am/, /aj/), 6 times each and 12 Japanese maxillectomy patients (Group 3) were asked to read only 3 monosyllables (/a/, /am/, /aj/) 6 times each. The “Nasalance Score” was calculated using a Nasometer (Nasometer II, model 6400 KayPentax, Lincoln Park, NJ, USA).

Results: Coefficient of variations (CVs) of three monosyllables /a/, /am/, /aj/ of Group 1 and Group 2 showed less than 0.33. There is significant difference in all pairs of three monosyllables between Group 1 and Group 3 (p < 0.05).

Conclusion: Using a Nasometer, these three monosyllables, /a/, /am/ and /aj/, could be used as standard test words and could reveal the level of air leakage in maxillectomy patients.

Key words: nasometer, nasalance, monosyllable, maxillectomy

Introduction
Maxillectomy often results in a high level of morbidity with significant psychological and functional implications for the patient. Such disabilities include inability to masticate and disturbances of deglutition and speech. The speech impairment as a result of surgical defect is likely to be the first problem encountered by patients. McGregor stated that the presence of oronasal communication eliminates or impairs the ability to seal off the nose, however, this impairment is eliminated with dento-maxillary obturator which can seal off the oronasal communication. Primary detection for the proper maxillary obturator will help patients to easily improve their swallowing and speaking efficiency.

One type of examination device, the Nasometer has been used as a noninvasive device for assessing nasal resonance. The Nasometer has been approved as a useful clinical tool for the assessment and diagnosis of nasality problems, when used in addition to a perceptual assessment. Several studies have reported the usefulness of the Nasometer in the assessment of resonance problems associated with velopharyngeal insufficiency and nasolabial obstruction. Several speech samples are included in the Nasometer package for the assessment of resonance disorders. Selections of different speech samples have been shown to affect the results. Previous research has shown that the Zoo Passage (devoid of nasal consonants) is useful in identifying individuals with velopharyngeal dysfunction and that the Nasal Passage is useful in identifying individuals with hyponasality. The Rainbow Passage (which contains 11% nasal consonants) is believed to represent the percentage of nasal consonants typical of conversational speech. However, the Rainbow Passage was found to be too difficult semantically and syntactically for young children.
In addition, Watterson et al. reported that the Zoo Passage was too difficult for children to repeat.10 These different speech samples have been used for perceptual judgments of hypernasality, and nasometric assessment varies in every language.9

Recently, Eckardt et al.11 stated that, after sufficient rehabilitation, with the proper dento-maxillary obturator, nasalance of maxillectomy patients can be normal. This means that using the Nasometer to evaluate the ability to seal off the oronasal communication in a maxillectomy patient is valuable.

Using a Nasometer, it is easy to determine the level of air leakage from an oronasal communication in maxillectomy patients, and to reduce the chair side adjustment time during the delivery of a dento-maxillary obturator.

It is necessary to determine optimal test words that are easy for patients worldwide to utter, for the comparison of data from international research; these words should be short in order to reduce the task and treatment time in postoperative patients faced with pain and depression.

In our preliminary study, the vowels that are all monosyllables, have a lot of sounds (some vowels are common in almost all languages over the world), easy to pronounce, were chosen to study their nasalance whether some of them can be used for this purpose. Vowels from the Thai language were chosen because of their varieties, 21 figures and 32 sounds. We found a large variety in nasalance scores among the entire vowels that had been chosen. Vowels that produced nasalance scores for which the proportion of standard deviations to the means (coefficient of variation, CV) was less than 1/3 were selected. We concluded that 3 monosyllabic vowels from the Thai language, /a/, /am/, and /aj/, could be standard test words; however, more research was required to clarify this.12 The purposes of this study were as follows: (Part 1) Identify suitable test words for the Nasometer test; (Part 2) Try to apply the test words in maxillectomy patients.

**Materials and Methods**

**Part 1: Identify suitable test words for the Nasometer test**

Forty normal subjects participated in this study and were divided into two groups. Group 1 included 20 Japanese adults, 24–36 years old, and Group 2 included 20 adults, 20–45 years old, from various races (international students of Tokyo Medical and Dental University), and 10 nations (Myanmar, China, Thailand, Bahrain, India, Bangladesh, Paraguay, Brazil, Peru, and Haiti). The exclusion criteria were a history of a maxillary defect of the palate and uvula, and problems with dental appliances (such as removable partial dentures and orthodontic appliances). Personal data, including history of medical and dental treatment related to voice and sound, such as sinusitis, rhinitis, and allergy, were recorded.

All subjects were tested with a Nasometer (Nasometer II, model 6400 KayPENTAX, Lincoln Park, NJ, USA). The Nasometer headset was adjusted to fit on a subject’s face and calibrated before use (as recommended by the manufacturer) (Fig. 1).

Subjects in Group 1 and Group 2 were asked to read 7 monosyllables (/a/, /i/, /u/, /e/, /o/, /am/, /aj/), 6 times each (Fig. 2).

The nasalance score was recorded and calculated during reading.

**Data analysis for part 1**

Data from both Group 1 and Group 2 were described in terms of character of each monosyllable and the CV was calculated to evaluate the reasonable test word.

Coefficient of variation (CV) = standard deviation/mean
Three Monosyllables for Nasometer Test to Evaluate Maxillectomy Patients

Results

Part 1
During the test, all subjects from both groups could pronounce the 7 monosyllables without difficulty. The nasalance scores are shown in Tables 1 and 2.

In the Japanese group, the monosyllables /a/, /am/, and /aj/ produced CVs of nasalance scores of less than 0.33; the CVs were 0.27, 0.23, and 0.32, respectively (Table 1).

In the international group, the monosyllables /a/, /am/, and /aj/ produced CVs of nasalance scores of less than 0.33; the CVs were 0.32, 0.18, and 0.33, respectively (Table 2).

When the mean nasalance scores for each of the monosyllables /a/, /am/, and /aj/ were compared by ANOVA, significant differences were observed between Group 1 and Group 2 (p < 0.05) (Fig. 3).

Part 2
When we compared the difference between the nasalance score of maxillectomy patients (Group 3) and the nasalance score of Japanese normal people (Group 1), we found a significant difference in each monosyllable (Fig. 4).

Table 1 Results from Group 1: Japanese subjects.

<table>
<thead>
<tr>
<th>/a/</th>
<th>/i/</th>
<th>/u/</th>
<th>/e/</th>
<th>/o/</th>
<th>/am/</th>
<th>/aj/</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>16.32</td>
<td>21.69</td>
<td>9.05</td>
<td>10.56</td>
<td>6.82</td>
<td>48.99</td>
</tr>
<tr>
<td>SD</td>
<td>4.40</td>
<td>12.11</td>
<td>5.63</td>
<td>7.55</td>
<td>4.11</td>
<td>11.17</td>
</tr>
<tr>
<td>CV</td>
<td>0.27</td>
<td>0.56</td>
<td>0.62</td>
<td>0.72</td>
<td>0.60</td>
<td>0.23</td>
</tr>
</tbody>
</table>

Table 2 Results from Group 2: International student subjects.

<table>
<thead>
<tr>
<th>/a/</th>
<th>/i/</th>
<th>/u/</th>
<th>/e/</th>
<th>/o/</th>
<th>/am/</th>
<th>/aj/</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>32.82</td>
<td>40.20</td>
<td>16.74</td>
<td>21.13</td>
<td>12.17</td>
<td>61.02</td>
</tr>
<tr>
<td>SD</td>
<td>10.38</td>
<td>18.80</td>
<td>9.21</td>
<td>13.91</td>
<td>6.64</td>
<td>10.90</td>
</tr>
<tr>
<td>CV</td>
<td>0.32</td>
<td>0.47</td>
<td>0.55</td>
<td>0.66</td>
<td>0.55</td>
<td>0.18</td>
</tr>
</tbody>
</table>

Fig. 3 Comparison of mean nasalance scores between groups 1 and 2, by pairing the same vowels (only /a/, /am/, /aj/), by ANOVA with SPSS software, showing a significant difference in all pairs between these two groups (p < 0.05).

Fig. 4 Comparison of mean nasalance scores between Group 1 and Group 3, by pairing the same vowels by ANOVA with SPSS software, showing a significant difference in all pairs between these two groups (p < 0.05).

References

Discussion
The first thing we realized during this test was how easy and convenient it was for all subjects to pronounce these monosyllables. Although all 7 of the monosyllables used in this study were chosen from the Thai and Japanese languages, they are easy to pronounce by people speaking other languages. The advantage of using monosyllables is that they are easy to utter and overcome the language barrier problem.

The three monosyllables, /a/, /am/, /aj/, resulted in nasalance scores with CVs of less than 0.33, both in the Japanese group and the international group. Similar to the results of our former study in Thai people, other monosyllables, such as /i/, /u/, /e/, and /o/, the basic vowels in many languages, resulted in nasalance scores with high CVs, over 0.33. We can conclude in the same context, three monosyllables, /a/, /am/, and /aj/, can be used as standard test words in Nasometer tests, without the limitations of language or ability to read and speak English.

Differences in native tongue had an effect on nasalance scores, even using the same test words. Like former studies using Nasometer tests, they tried to prove their disagreement in using the same mean nasalance score in different population. Previous studies in normal speakers indicated that nasalance scores vary across languages and across dialects. Seaver et al.\textsuperscript{19} found significant differences in nasalance scores among speakers of American English, and suggested that clinicians might need to establish regional norms to assess patients with nasal resonance problems. To date, no normal nasalance scores have been published for English speakers in the United Kingdom or Ireland. These authors also indicated the importance of considering differences in nationality, age, and even regions within the same country, when using the standard 3-test passages described above or using their own language passages\textsuperscript{16-18}

Although the results of the international group (20 subjects from 10 nations) showed an unique result with others, CVs did not exceed 0.33, this has confirmed the potential worldwide use of these three monosyllables. It seems to be possible to find a norm for the general population by working in wide field research and proper design in sampling the subjects from those populations. However, there was a significant difference in mean nasalance scores between Group 1 and Group 2. In order to use these 3 monosyllables as standard test words in speakers of specific native languages, mean nasalance scores for each monosyllable should be determined in those native language populations.

From the results of part 2, the vowels /a/, /am/, and /aj/ also have CVs lower than 0.33, the same as both normal sample groups. It, confirms the reliability of the test with these three monosyllables that it will give us the authentic measurement when used with maxillectomy patients and the nasalance scores of those who have oronasal communication are patently different from the normal people. These three monosyllables can be used, with Nasometer, as an evaluation method to measure the level or severity of air leakage in maxillectomy patients.

One previous study to shorten the standard test passage for Nasometer was performed by Watters and Lewis in 1999.\textsuperscript{19} These authors chose the passage recommended by Karnell in 1995, with 44 syllables, and shortened it to 17, 6, and 2 syllables. Although they suggested not using the 2 syllable test, their paper had an interesting question in the discussion about the effect of vowels. They suggested that nasalance scores are vowel dependent, and that the answer is less clear if speech samples contain only one vowel.\textsuperscript{19} They asked for further study on this issue and this study could provide more information that each vowel individually affects nasalance and might be the key to be the test word itself.

Considering these three monosyllables, in term of linguistics, /a/ is a plosive sound with closure of soft palate, /am/ is a nasal sound with closure of lips, and /aj/ may be a semivowel sound.\textsuperscript{20} If these are true in terms of physiological function during pronunciation, we can use /a/ instead of the Zoo passage, /am/ instead of the nasal sentence, and /aj/ instead of the Rainbow passage. To prove this hypothesis, we need to design another research project that observes velopharyngeal function during the pronunciation of these 3 monosyllables. One method for this would be to watch the physiology of speaking using a fibroscope and cephalography or videofluoroscopy. Preliminary results from a Japanese volunteer study support our hypothesis. However, the risk of side effects, including overdose of radiation and laceration wound in nasal and velopharyngeal cavities\textsuperscript{21} have prohibited us from conducting further studies.

Supporting results from future clinical research,
large population field studies, and cross native languages are needed to prove and clarify the exactly complete substitution in usefulness of the 3 monosyllables to conventional passages in Nasometer tests, especially for the primary evaluation of maxillary obturators as a result of patient data.

**Conclusion**

In Nasometer tests, the three monosyllables /a/, /am/, and /aj/ can be used as standard test words for ordinary people. These three monosyllables can be used for the primary detection of improper function of dento-maxillary prostheses, especially maxillary obturators. However, there was a significant difference in mean nasalance scores between 20 normal Japanese (Group 1) and 20 international adults (Group 2); thus, it means nasalance scores for these monosyllables, as standard values, should be determined for each language. As this was a fundamental study, further clinical studies are required to clarify the efficiency of these three monosyllables.

**Appendix**

**ZOO PASSAGE**
- Look at this book with us. It’s a story about a zoo. That is where bears go. Today it’s very cold out of doors, but we see a cloud overhead that’s a pretty white fluffy shape. We hear that straw covers the floor of cages to keep the chill away; yet a deer walks through the trees with her head high. They feed seeds to birds so they’re able to fly.
- Contains no nasal phonemes
- Native English speaker = 16.295% (standard deviation = 5.915)

**RAINBOW PASSAGE**
- When the sunlight strikes raindrops in the air, they act like a prism and form a rainbow. The rainbow is a division of white light into many beautiful colors. These take the shape of a long round arch, with its path high above, and its two ends apparently beyond the horizon. There is, according to legend, a boiling pot of gold at one end. People look, but no one ever finds it. When a man looks for something beyond his reach, his friends say he is looking for the pot of gold at the end of the rainbow.
- Contains 11.5% nasal phonemes
- Native English speaker = 34.37% (standard deviation = 6.225)

**NASAL SENTENCES**
- Mama made some lemon jam.
- Ten men came in when Jane rang.
- Dan’s gang changed my mind.
- Ben can’t plan on a lengthy rain.
- Amanda came from Bounding, Maine.
- Contains 35% nasal phonemes.
- This percentage is more than three times of what is expected for standard American English sentences.
- Native English speaker = 60.51% (standard deviation = 7.08)

**References**
10. Watterson T, McFarlane S, Wright DS. The relation-