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Mandibular setback and its effects on speech☆

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A B S T R A C T

Purpose: To study effects of mandibular set back by BSSRO on phonetic quality of vowel sounds and compare it with preoperative recording.
Patients and methods: Ten non syndromic male patients of mandibular skeletal excess between 16 and 24 years of age undergoing pre-surgical Orthodontic treatment were included in the study. Before surgery vowel sounds in Hindi language were recorded by suitable software. The patients were treated by bilateral sagittal split ramus osteotomy for mandibular setback. Postoperatively same sets of sounds were recorded at an interval of 4, 8, 12, 24 and 52 weeks. The acoustic features were divided into two groups: F_1 being vowel sounds of posterior region (Oropharyngeal) and F_2 being vowel sounds produced in the anterior region. The data analysis was done using Praat software (ver 5404).
Results: A total of 10 male patients were selected with an average age of 17.4 years. Amount of mandibular setback on an average was 6 mm. It was observed that frequency values of F1 reduced after the surgery till 12 weeks following which it improved to its preoperative status. F2 values increased postoperatively and continued to be higher than the preoperative values throughout the follow up period.
Conclusion: Mandibular set back by bilateral sagittal split osteotomy have profound influence on the acoustic qualities of the subjects. In our study it was realised that, such changes are attributable to changes in transverse and vertical changes of the oro-phyarngeal and oral apertures respectively.

1. Introduction

Orthognathic surgeries have been widely used in treatment of various congenital and acquired defects of the cranio-maxillofacial region. They have profound bearing on the aesthetic outcome. It has been established by studies that this procedure brings about remarkable changes in dimensions of the upper airway; however, effect of such a procedure on phonation has been scantly investigated. Previous acoustic analysis have relied upon evaluation of speech therapists and experts, adding subjectivity to the study. Studies conducted by Ladefoged proposed that using acoustically measured values helped in auditory qualification of vowel sounds [1]. This resulted in evaluation of vowel sounds and their quantification that could be used for statistical analysis and arrive at definitive conclusions [2].

Procedures like bilateral sagital split osteotomy (BSSO) affects the position of tongue, teeth and peri-oral musculature, may have profound effect on speech. In recent past various techniques have been used by researchers in conducting speech evaluation: radiographic evaluation of hyoid bone position is one of them. The demerits of technique are being: indirect technique and hyoid bone position returns back to normalcy, may give erroneous outcomes [3].

Clark and Yallop analysed acoustic characteristics based on changes in shape of mandible and position of tongue [4]. In 2006 studies were carried out by Nemi et al. who segregated formant values into F_0,F_1 and F_2 in five cases of Class II malocclusion who underwent BSSO [5].

The pronunciation of consonants has shown to have distortion from person to person. Use of vowel sounds gives us appropriate analysis of position of tongue and mandible and also is least influenced by position of lip and teeth [6]. Lindblom and Sundberg found that F1 is affected by patency degree of the jaw and that F2 is affected by the movement of tongue [7].

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2. Materials and methods

This prospective study was conducted at the Department of Oral and Maxillofacial Surgery of a tertiary level teaching hospital from January 2011 to December 2013 after obtaining due permission from Institutional ethical committee. Informed written consent was obtained from the patients prior to study.

A total of fifteen Indian male patients, aged 16–25 years who had undergone pre-surgical orthodontic treatment were included. Individuals who had any history of previous oto-laryngeal surgery, syndromic mandibular prognathism, systemic illnesses, defective hearing and speech, adjunctive procedures like genioplasty or bijaw surgery were excluded.

All selected cases underwent pre-surgical orthodontic treatment. Before surgery voice recording was carried out using a microphone (i Ball inc: 164229919) maintaining a mouth piece and mouth distance of 10 cm and was analysed using Praat software (ver ver 5.1.31, Phonetic services university of Amsterdam, Netherlands) [Figure-1]. Individuals were asked to pronounce vowel sounds in Hindi vernacular.

The vowel list of pronunciation procedure consisted of words '*ah*' अ 'aa' आ 'eh' ः 'eeh' ई, these four vowel sounds were flashed onto a screen at 2.5 s interval each and subjects were told to repeat the words aloud. Selected vowel sounds were divided into two groups: F_1 consisting of words 'ah' and 'aa' and F_2 consisting of words 'eh'and 'eeh'.

Subjects underwent mandibular setback using BSSO under GA by a single surgeon. Amount of set-back carried was from 5 mm to 8 mm.

Recordings were repeated post-operatively at 4, 8, 12, 24 and 52 weeks interval.

Data management was done using Excel spreadsheet (Microsoft Inc) and data analysis was done to evaluate significance of differences in acoustic correlates of articulatory parameters measured pre-operatively and 4,8,12,24 and 52 weeks post-operatively (SPSS ver 11.5). [Table 1].

3. Results

1. Four weeks post surgery:

There were significant changes in values of F_1 for the words '*ah*' and '*aah*' which had decreased to a frequency value of 3148 Hz and 3185 Hz respectively 4 weeks post-surgery in comparison to pre- surgical values of 3366 Hz and 3465 Hz. Whereas values for F_2 for the words and ('*eh*' and '*eeh*') the frequency value had also decreased to 3053 Hz and 3219 Hz respectively in comparison to 3250 Hz and 3454 Hz in the pre-operative stage.

2. Eight weeks post surgery:

Compared with pre-operative status and eight weeks post-operative, acoustic changes were statistically significant with still a decrease in frequency of vowels of F_1 group as well as the F_2 group. However values had shown a slight increase in frequency in comparison to 4 weeks post-operative values.

3. Twelve weeks post surgery:

Compared with pre-operative status of acoustics and 12 weeks post-operatively, there were slight changes in levels of frequency of vowels for group F_1. However, there were significant changes for vowels in F_2 group which had increased in frequency to 3395 Hz and 3687 Hz for vowels '*e*' and '*eeh*' respectively.

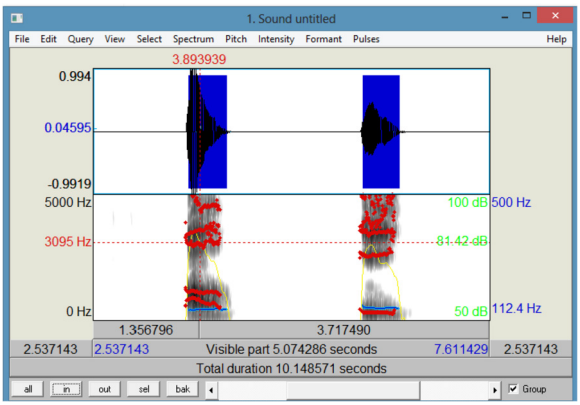

Fig. 1. Acoustic recording using Praat software.

Table-1
Pre-operative and 4,8,12,24 and 52 weeks post-operative follow-up of acoustic analysis of vowel sounds.

	Vowels (frequency in Hz)			
	A (n = 15)	Aa (n = 15)	E (n = 15)	Ee (n = 15)
Pre-op	3366.4 ± 176.3	3464.9 ± 190.1	3250.3 ± 704.2	3453.6 ± 610.4
Post-op 4 Weeks	3147.6 ± 186.2	3185.3 ± 244.6	3053.4 ± 642.6	3218.6 ± 649.5
Post-op 8 Weeks	3311.6 ± 212.2	3271.5 ± 215.5	3359.8 ± 708.4	3645.6 ± 432.1
Post-op 12 Weeks	3331.0 ± 201.1	3335.9 ± 165.2	3394.8 ± 660.3	3686.8 ± 695.7
Post-op 24 Weeks	3343.0 ± 288.1	3327.6 ± 145.7	3293.8 ± 615.4	3684.2 ± 694.4
Post-op 52 Weeks	3363.0 ± 179.0	3468.4 ± 171.4	3317.9 ± 584.7	3463.7 ± 535.8
Comparisons [P-values]				
Pre-op v/s Post-op 4Wks	0.001 (S)	0.001 (S)	0.001 (S)	0.001 (S)
Pre-op v/s Post-op 8Wks	0.041 (S)	0.001 (S)	0.001 (S)	0.040 (S)
Pre-op v/s Post-op 12 Wks	0.101 (NS)	0.025 (S)	0.008 (S)	0.001 (S)
Pre-op v/s Post-op 24 Wks	0.649 (NS)	0.010 (S)	0.475 (NS)	0.001 (S)
Pre-op v/s Post-op 52 Wks	0.626 (NS)	0.697 (NS)	0.116 (NS)	0.726 (NS)

Hz: Hertz.

4. Twenty four weeks post operative:

Compared to pre-operative acoustic status; 24 weeks post operative results showed significant changes with decrease in frequency of F_1 sounds and increase in frequency of F_2 sounds. However, values were greatly increased as compared to 12 weeks post-operative values.

5. Fifty two weeks post operative:

Compared to pre-operative acoustic status the 52 weeks post operative results showed mild changes with frequency values approaching pre-operative values for F1 and increase in frequency for F2, indicating improvement of F1 sounds to near normal and that of F2 to drastic improvement from pre-operative values [Figure-2].

4. Discussion

Formants are distinguishing frequency components of human articulation. Formant with lowest frequency is known as F1, that with the second lowest frequency is known as F2, and that with third lowest frequency is known as F3. The two first formants, F1 and F2, are usually sufficient for disambiguating vowel and determining quality of vowels in terms of open/close and front/back dimensions. Hence, in this study we have considered on F_1 and F_2 frequencies.

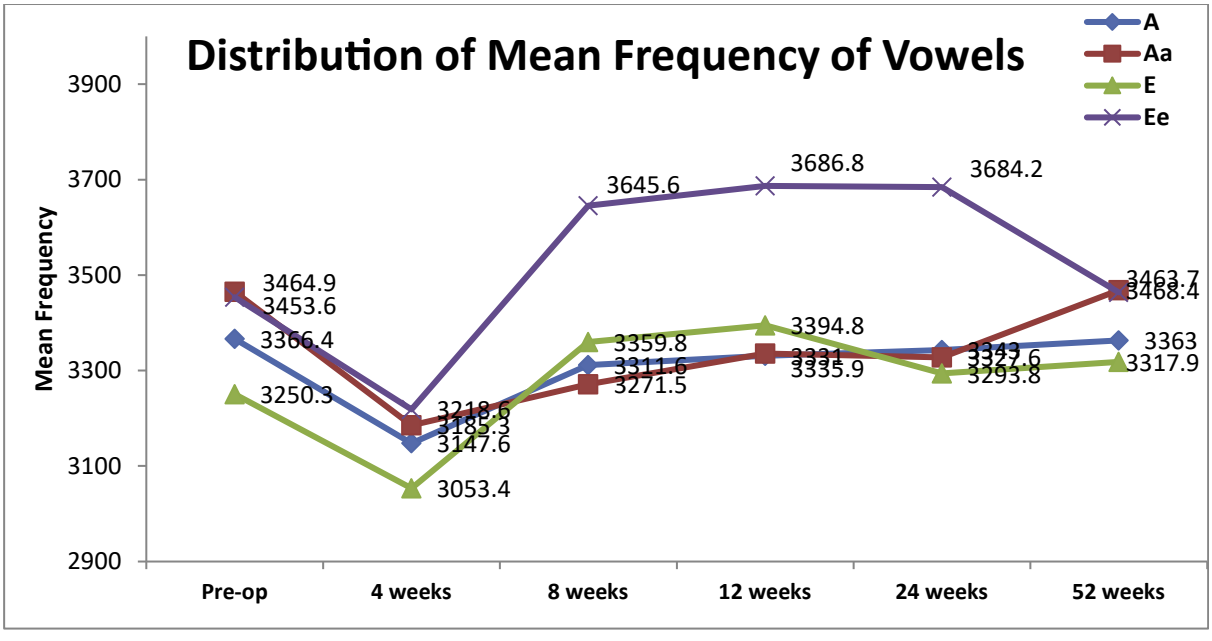

Fig. 2. Pre- operative and post operative results of analysis of vowel sounds.

Studies conducted in the past have focussed on position of mandible or oro-pharyngeal cavity and have considered use of radiological assessment and not acoustics [8]. These studies reported a change in position of hyoid bone and reduction in dimensions of retrolingual and hypopharyngeal airway after mandibular setback surgery [9–11]. Nevertheless, some studies have included phonetics as a part of research but have considered only consonant sounds and not vowels [12]. Formant method, which is used in the field of phonetics, has the advantage of analysing the structural changes in the vocal tract [13]. Hence, formant was used in our study.

Use of acoustics has focussed on phonetics with respect to English language, as the study was conducted in Indian subcontinent, there was need to use vernacular language, but at the same time study needed to avoid confounding bias, hence vowels of Hindi language was used in our study.

Results of the study showed significant statistical changes in formant values of frequency, as frequency values of F_1 increased and that of F_2 decreased, indicating anatomic changes in back and front vowels, with increase in vertical dimension at the incisor region and horizontal change in the oro-pharyngeal regions. The results were similar in comparison of study conducted by Ahn J et al. [14].

Values showed significant changes upto 8 weeks post-operatively with decrease in frequency of F_1 which authors envisage it to either settling of soft tissue post surgery or due to adaption of tongue to its new position created post surgery. However, values appeared to be skewed in 12 weeks–post operative phases. Nevertheless, changes revealed a slight increase in frequency of F_1 suggestive of narrowing of oro-pharyngeal aperture. However, values of F_2 showed increases in value of frequency till the end of this phase indicating increase in oral aperture due to increase in inter-incisal distance.

The values 24 weeks post-operatively did not show many changes as compared to 12 weeks post-operative phase. In comparison to pre-operative and 8 weeks post-operative values. Values of F_1 had lower values and F_2 continued to have higher values. Indicating increase in horizontal dimension of oro-pharyngeal aperture and increase in vertical dimension of inter-inicisal distance.

Values for both F_1 and F_2 showed no statistical significance 52 weeks post-operatively as they had achieved near values of that observed pre-operatively, hence to prove that bilateral saggital split osteotomy for set-back has no long term effect on outcome of speech.

Studies conducted by Liukkonen et al. [15] there is a narrowing of the posterior airway space due to posterior-caudal rotation of the mandible following set-back, which may have lead to speech changes in initial periods of follow-up for post-pharyngeal sounds (F_1). The reason of return of near normal pre-operative values could be due to re-adaption of soft tissue resulting in partial or complete resolution which is comparable to studies conducted by Chen et al.; Enacar et al., and Samman et al. [16, 17, 18].

5. Conclusion

There were significant changes in acoustics between pre-operative and post-operative vowel sounds in the initial follow-up period, owing to changes in articulating dimensions after the procedure. However, soft-tissue adaptation over to its near normal value as seen pre-operatively. Study of this type requires attention to detail and we recommend that pre-operative analysis of phonetics must be done all cases undergoing orthognathic surgeries.

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent

Informed consent was obtained from all individual participants included in the study.

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