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A Cross-Sectional Study of Comparing Diadochokinesis Parameters Between Normals and Post-Mandibulectomy

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Abstract

Background and Aim: Oral cancer has been the second most common cancer in India. Mandibular cancer has been in raise due to the use of tobacco-related products. The influence of mandibular cancer before and after surgery has not been studied much. Hence, the current study aimed to evaluate the effect of mandibulectomy on mandibular stability through the assessment of diadochokinetic measurement. **Materials and Methods:** Thirty-nine subjects served as participants for the present study. Out of which, 30 normal (group 1) and 9 individuals of the mandibular lesion (group 2) as a clinical group. Study material included rapid repetition of bilabial /pa/, alveolar /ta/, velar /ka/ and /pataka/ sequence for 6 seconds duration. Three trials have been obtained from all participants. Data were analyzed using Praat software and an independent t-test and paired t-test was used for statistical analysis. **Results:** Results showed a reduced SMR rate as compared to the control group in the postoperative condition. AMR rate of only /pa/ syllable was found to be statistically significant at a lower rate in post-operative conditions. The acoustic parameters of syllable duration, inter syllable duration, and peak intensity of each consonant /p/, /t/, and /k/ did not vary across groups. **Conclusion:** The study indicated that the mandibular stability was found to be reduced following mandibulectomy. The reduced AMR rate of /pa/confirmed the effect of mandibular surgery on the production of anteriorly positioned speech sounds. The present study stresses the importance of incorporating the DDK parameters in speech assessment to understand mandibular stability.

Keywords: Mandibulectomy, DDK, speech motor coordination

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Introduction

Diadochokinetic rate (DDK) measurements reflect the motor speech coordination and also raising and lowering of the mandible or protrusion and retracting the tongue. [1] It provides information on speed, accuracy, and continuity measures of speech production. [2].

DDK measurements are carried out by rapid repetition of syllables bilabial /pa/, alveolar /ta/, and velar /ka/ and /pataka/. Studies have reported that DDK provides information on variation observed in mandibular stability.[3] The mandibular lesions can contribute to anatomical changes thus affecting mandibular stability.

Need for the Study

There has been a very limited study on DDK rates in individuals who have mandibular cancer or the individuals who underwent mandibulectomy. There is a need to carry out a longitudinal study by comparing the performance of speech motor control mechanisms before and after they undergo mandibulectomy. There is also a dearth in studies comparing the normative group with mandibular lesions for understanding the effect of lesion on motor speech coordination. A comparison of a normative group with individuals who have undergone mandibulectomy can also assist the speech pathologists and surgeons in providing knowledge of the mandibular stability of patients.

Aim of the Study

The present study focusses on finding out how much does the motor speech ability gets varied in a group of individuals after mandibulectomy before and after the surgery.

Objectives of the Study

To investigate the variation in verbal diadochokinetic rates between

1) Preoperative condition of individuals with mandibular cancer and normative group
2) Postoperative condition of individuals after mandibulectomy and normative group
3) Preoperative condition of individuals with mandibular cancer and post-operative condition of individuals after mandibulectomy

It is hypothesized that the individuals' post mandibulectomy will have a reduced rate as compared to the preoperative condition and normative group.

Method

The participants of the study were all native speakers of Kannada, from Bangalore, Karnataka. The participants were grouped into 2, control group and clinical group. Control Group

included 30 normal individuals (15 males, 15 females) with age ranging from 25 to 70 years, with no oro maxillofacial deformities, the second group was the clinical group which comprised of 9 patients (5 females, 4 males).

Sample Size Estimation

Based on the hospital registry since the survival rate of the mandibular cancers after mandibulectomy without recurrence is comparatively lesser than the individuals with mandibular lesions, purposive sampling was adopted for selection of patients. All the individuals who approached to the hospitals with mandibular cancer and who survived healthy without any recurrence after 3 months post operatively was considered for the study.

Study Duration

The study duration of 1 year 6 months were considered for data collection, January 2019 to June 2020.

Study Design

Cross-sectional study design

Ethical Consideration

The current study obtained permission from the hospital's ethical committee with an approval number CIEC/OB06/2019.

Informed Consent

An informed consent form was taken from the participants before carrying out speech recording [Appendix - 1].

Participant Selection Criteria

The following inclusion and exclusion criteria were adopted for the selection of the participants in the clinical group for the study,

Inclusion Criteria

1) Individuals in whom the diagnosis of cancer of mandible has been confirmed based on their clinical and histopathological findings
2) No history of hearing loss
3) Not received any treatment for any other oral cancer lesion
4) Proficiency to speak in Kannada
5) Individuals who had not received any speech therapy post-oral surgery included in the present study.

Exclusion Criteria

1) Patient with
2) Recurrence of oral cancer
3) Extensive lesion in the oral cavity affecting the function of articulators other than the maxilla and mandible.
4) Impaired Neurological function / cognitive function.
5) Auditory comprehension deficit
6) History of hearing loss and visual impairment were excluded from the study.

Based on the inclusion and exclusion criteria 9 patients were recruited for the current study [Table – 1].

PROCEDURE

Patients were made to sit at a 90-degree angle with back support at their most comfortable seating posture. The mouth to microphone distance was maintained at 10 cm distance by holding the recorder in hand after measuring the distance with a ruler.

The speech recording was done on two occasions for the clinical population.

1) Occasion 1: 1 or 2 days before surgery
2) Occasion 2: 2 to 3 months after surgery.

The speech samples were recorded at a sampling rate of 44,100 Hz and with 16-bit quantization. All performances were recorded in Sony ICD-PX240 MP3 Digital voice IC recorder. The device has a built-in microphone and is monaural. The noise cut feature is present with a frequency response between 75 to 15,000 Hz, this filter setting allows for better speech recording.

The participants were oriented about the study and informed consent was taken. They were instructed to repeat the monosyllabic sequences bilabial /pa/, alveolar /ta/ and velar /ka/ and the trisyllabic sequence /pataka/ as fast as possible for at least 6 s. A trial run was done to make them understand the instructions and follow the procedure. The count-by-time method was used during the first 5 s of the sequence. [4,5]

SL. No.	Name of Patients	Age/ Gender	Type of mandibular lesions	Type of mandibulectomy & reconstruction
1	RJH	67years/M	Mucoepidermoid carcinoma on right retromolar area, anteroposteriorly extending from distal side to retromolar T4aN0M0	Right marginal mandibulectomy
2	AFJ	45 years/F	Well defined solid cystic lesion in the left retromandibular as well as around the ramus of the mandible T4aN2aM0	Left segmental mandibulectomy and parotidectomy
3	PR	54 years/M	Right submandibular lesion – metastasis, Ca Buccal mucosa T2N1M0	WLE and right hemi mandibulectomy and reconstruction with PMMC
4	TJS	40 years/F	Lesion encasing ramus of mandible with associated erosion of mandible infiltrating to the right masseter muscle T4aN1M0	Wide excision, total parotidectomy, and segmental mandibulectomy and free flap reconstruction.
5	KBJ	63 years/M	Left lower alveolus proliferative growth in left the last molar. T4aN0M0	Segmental mandibulectomy and left SND and left SOHND and left infrahyoid flap reconstruction.
6.	MJM	58 years/F	Ulcers proliferative growth left retromolar trigone extending to the left buccal mucosa T2N0M0	Left marginal mandibulectomy and WLE and reconstruction with infrahyoid flap
7.	SHV	64 years/M	Proliferative growth in right RMT and lower GBS and buccal mucosa T4aN1M0	Right mandibulectomy and right superior alveolectomy, reconstruction with PMMC.
8.	GWR	60 years/F	Ca right buccal mucosa, gingiva buccal sulcus, and retromolar area T4aN2cMx	Right segmental mandibulectomy with reconstruction with PMMC harvested from the parasternal area
9.	SHD	65 years/F	Proliferative growth in RMT and buccal mucosa and lower GBS	Right hemi mandibulectomy with PMMC reconstruction

Table 1: Description of mandibular lesions and type of mandibulectomy and reconstruction.

Data Collection

Data was collected on a one-to-one basis in a quiet room which was specially designed for recording with no echo formation. The noise in the room was monitored with the help of a VU meter of Praat software.

All participants had to do perform the DDK tasks for 3 trials and the average of 3 trials during this maximum performance task was used in the statistical analysis. The participants were instructed to take in a deep breath and repeat syllables each syllable (/pa/, /ta/ & /ka/) without interruption for approximating the production of the sequence of /papapa/ or /tatata/or /kakaka/ or /pataka/.

Analysis

The recorded DDK samples were then digitalized as sound files ready to be analyzed using the PRAAT software. The premier software tool, Praat, Version 6.0.21, developed by Paul Boersma & David Weenink, 2016 was used for the analysis [6].

DDK productions were acoustically measured using Praat with the rationale that it provides an acoustic index of the speed of articulatory movement and positioning [7].

The following are the parameters considered for acoustic analysis of DDK

a) DDK Rate

To obtain the DDK rate, the number of syllables was counted by manually counting the number of peaks in the intensity waveform and obtaining information on the duration of production from the x-axis of the spectrograph (Fig 1).

The DDK Rate was calculated by using the following formula,

DDK rate = Total number of syllables produced in 5 seconds

The unit of measurement will be the number of syllables per second. This provided the value of the DDK rate.

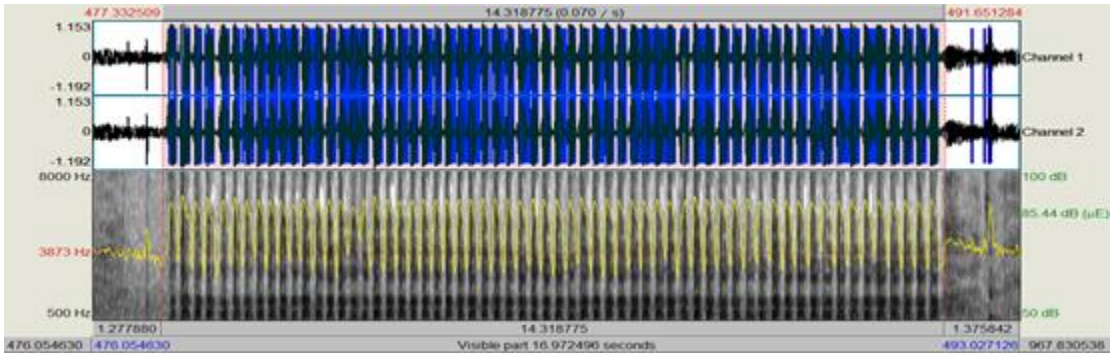

Figure 1: The image represents intensity peaks of /ka/ which is yellow, each peak represented the production of /ka/. The time is represented in the x-axis of the spectrograph.

For calculating the Sequential Motion Rate (SMR) rate, the number of all the syllables /pataka/were counted together. Figure 2 indicates image of /pataka/ sequence. Hence the value of SMR was noted as the number of syllables per second. Each peak was identified as the production of one syllable

SMR Rate = Total number of syllables produced in 5 seconds

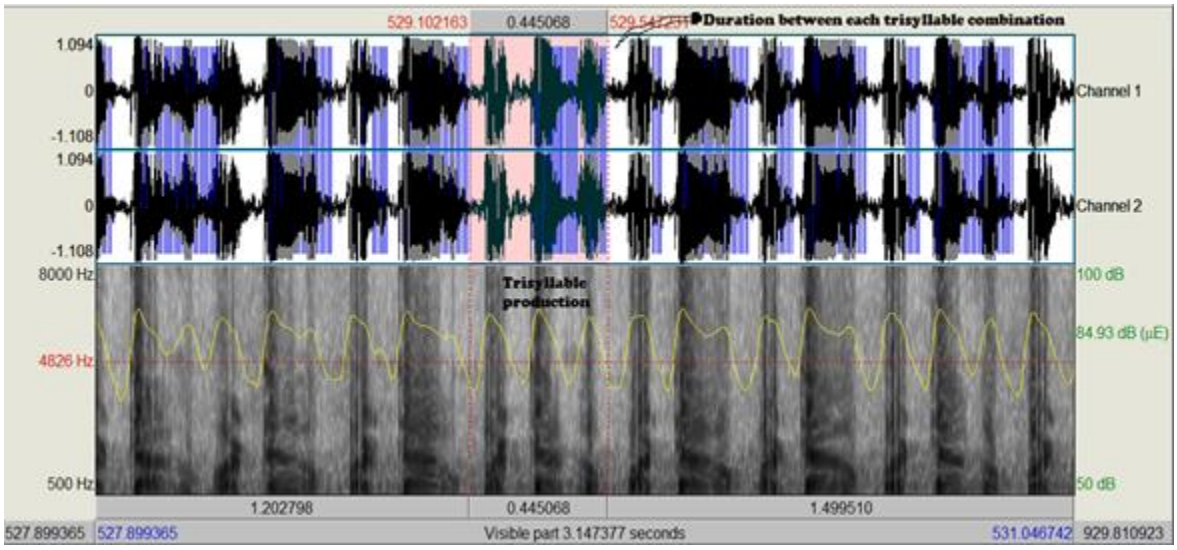

Figure 2: This image represents the production of /pataka/ by a participant.

b) Consonant Vowel (CV) Syllable Duration (SD)

The CV syllable duration was measured considering the burst onset and the end of the vocalic nucleus (Fig. 3). The CV syllables were taken from the beginning of the signal, the middle portion of the signal, and the end of the signal. All the three-syllable durations were averaged to finalize the CV syllable duration.

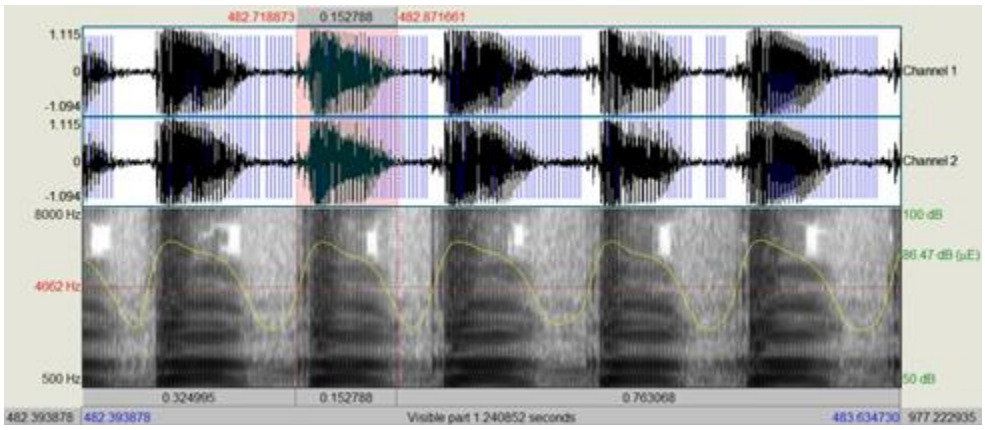

Figure 3. This figure indicates the selection of CV syllable /ka/ for identifying each syllable duration.

For each executable DDK speech sample, consonant-vowel syllable duration of the initial, medial, and final segments of the signal were selected and the average of these 3 durations was calculated to reach into final calculation of CV syllable duration. This was calculated for /pa/ /ta/ and /ka/.

c) Inter Syllabic Duration (ISD)

For all CV syllables to generate temporal and intensity parameters instantly the average period between the CV syllables was measured between the voicing offsets of the syllables, i.e., between the negative slopes at the end of the syllables at the points crossing the threshold (Fig 4).

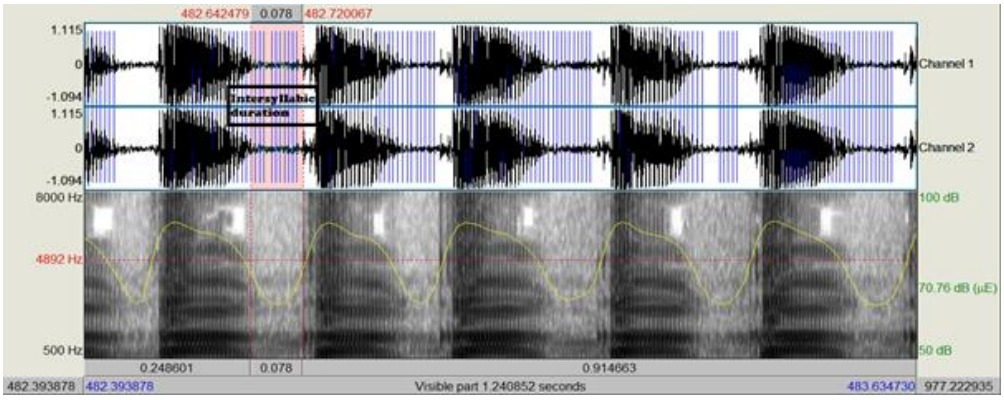

Figure 4. The highlighted portion of this image indicates the intersyllabic duration.

The intersyllabic duration of initial, medial and final segment portions of the signal were calculated and the average of these 3 values was taken as the final product of intersyllabic duration. This was calculated for /pa/, /ta/, and /ka/ speech segments.

d) Peak Intensity (PI) measurement of /pa/, /ta/ and /ka/

The peak intensity of each consonant was calculated by selecting only the consonant part without vowel and analyzing its respective intensity contour. The peak intensity of each consonant was measured (Fig 5).

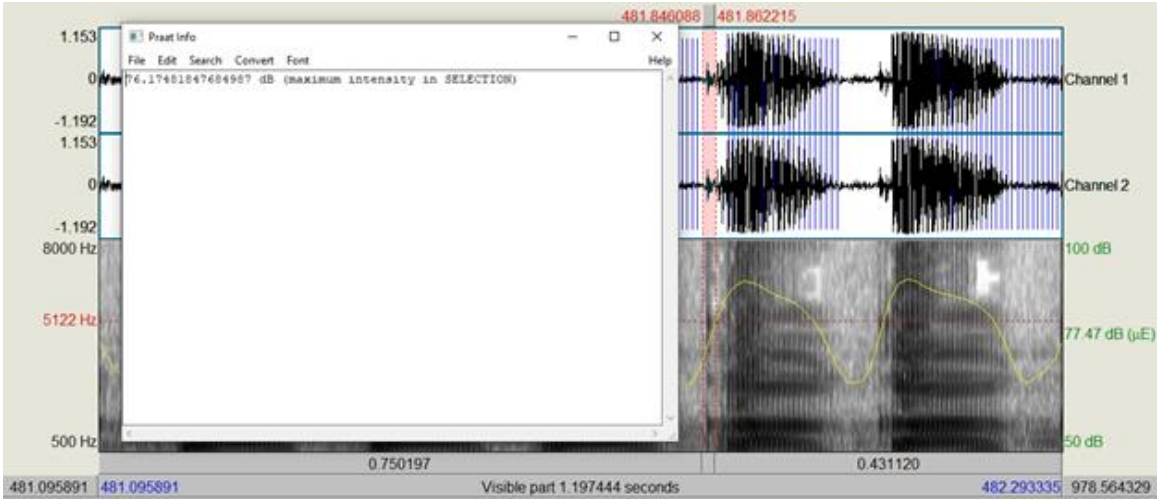

Figure 5: The image represents the selection of /k/ potion of the signal and Praat information of maximum intensity obtained for this signal.

Statistical Analysis

The mean and standard deviation were computed for all the raw data obtained from the study. Statistical analysis was carried out by using SPSS 20 package. The following statistical application was computed:

- An independent sample t-test was used for comparison of values obtained for normative group vs clinical group in the preoperative condition and normative group vs clinical group in post-operative condition.
- A paired t-test was used for comparing values obtained for the preoperative condition and post-operative condition of a clinical group.

Results

Overall, a corpus of 360 trials of syllable sequences was analyzed which included the normative group, pre and post-operative conditions of a clinical group. These syllable sequences were analyzed for understanding variation in DDK rate (AMR & SMR), CV syllable duration, Intersyllabic duration, and Peak intensity measurement of bilabial /pa/, alveolar /ta/, and velar/ka/.

DDK Rate

AMR & SMR

The result of AMR of /pa/, /ta/, and /ka/ revealed that the AMR rate was the number of syllables produced was higher in the normative group as compared to pre and post-operative condition of a clinical group. Among the pre and post-operative conditions, the number of syllables of /pa/ and /ka/ produced among post-operative conditions was slightly reduced than preoperative conditions. There was a slight increase in the number of /ta/ syllables produced by the clinical group in preoperative conditions than post-operative conditions. Statistical analysis indicated there was a statistically significant reduction (*P* 0.003) found only in AMR of /pa/ in post-operative condition as compared to the normative group and preoperative condition. (Table 2.)

The SMR values were observed to be greater among the normative group as compared to the clinical group. Though there was a reduction in the number of syllables per second in the post-operative condition of the clinical group as compared to their preoperative condition and normal group. This difference was found to be statistically significant (*P* 0.002) only between normative and post-operative conditions. (Table 2)

Syllables	Control Group		Clinical Group				Control group Vs Occasion 1	Control group Vs Occasion 2	Occasion 1 Vs Occasion 2
	Normal		Pre-Operative Condition (Occasion 1)		Post-Operative Condition (Occasion 2)		p-value	p-value	p-value
	Mean	SD	Mean	SD	Mean	SD			
/pa/	5.54	0.52	5.00	0.70	4.86	0.31	0.083	**0.003**	0.305
/ta/	5.57	0.87	4.64	0.40	5.12	0.75	0.204	0.096	0.706
/ka/	5.18	0.70	5.00	0.70	4.72	0.70	0.855	0.215	0.339
/pataka/	7.93	1.033	7.40	1.342	6.20	0.447	0.364	**0.002**	0.109

Table 2: AMR & SMR values obtained among normative, pre-operative and post-operative group

CV Syllable Duration, Peak Intensity, and Inter-syllable Duration

The finding of the study revealed that the syllable duration, peak intensity, and inter-syllable duration of /pa/, /ta/, and /ka/ were not significantly different between the groups. This reflected that the normative group and clinical group did not differ in terms of syllable duration, peak intensity, and inter syllable duration during the production of each syllable (Table 3, Table 4, and Table 5).

Syllables	Control Group		Clinical Group				Control group Vs Occasion 1	Control group Vs Occasion 2	Occasion 1 Vs Occasion 2
	Normal (Group 1)		Pre-Operative Condition (Occasion 1)		Post- Operative Condition (Occasion 2)		p-value	p-value	p-value
	Mean	SD	Mean	SD	Mean	SD			
/pa/	0.126	0.011	0.116	0.018	0.144	0.018	0.169	0.143	0.200
/ta/	0.138	0.028	0.136	0.015	0.136	0.023	0.518	0.706	0.807
/ka/	0.146	0.029	0.150	0.045	0.142	0.013	0.498	0.773	0.683

Table 3: Syllable duration (SD) of /p/, /t/ and /k/ obtained across groups

Syllables	Control Group		Clinical Group				Control group Vs Occasion 1	Control group Vs Occasion 2	Occasion 1 Vs Occasion 2
	Normal Group PI (dB)		Pre-Operative Condition (Occasion 1)		Post- Operative Condition (Occasion 2)		p-value	p-value	p-value
	Mean	SD	Mean	SD	Mean	SD			
/pa/	88.14	2.18	87.73	4.62	88.82	1.44	0.791	0.612	0.707
/ta/	86.92	2.80	88.69	1.56	89.03	1.77	0.166	0.169	0.992
/ka/	87.65	2.67	88.83	1.40	88.49	2.03	0.299	0.530	0.692

Table 4: Peak Intensity (PI) of CV syllable duration obtained for syllables across groups.

Syllables	Control Group		Clinical Group				Control group Vs Occasion 1	Control group Vs Occasion 2	Occasion 1 Vs Occasion 2
Syllables	Normal		Pre-Operative (Occasion 1)		Post-Operative (Occasion 2)		p-value	p-value	p-value
	Mean	SD	Mean	SD	Mean	SD			
/pa/	0.048	0.022	0.062	0.013	0.040	0.014	0.818	0.551	0.195
/ta/	0.033	0.013	0.046	0.015	0.038	0.008	0.153	0.369	0.587
/ka/	0.036	0.015	0.044	0.013	0.040	0.012	0.857	0.668	0.621

Table 5: Inter Syllabic Duration (ISD) obtained between single syllabic productions obtained for control and clinical group.

Discussion

The reduction in AMR measurement of /pa/ syllables in the postoperative group indicated reduced movement of jaw. This can be attributed due to the effect of the impairment in base of speech production i.e., the mandible. Studies have reported that the oral-DDK reflects neuromotor maturation and integration of the orofacial structures involved in speech, for instance, tongue and lips.[7,8,9] Thus reduced alternative and repeated movement of /pa/ indicates reduced rate and range of movement of the mandible in the postoperative group as an effect mandibulectomy. This finding was in line with findings stated that deficits in oro motor musculature will be reflected in the reduced speed of movement of articulators. [10]

Literature reported that the greatest concentration of cortical bone within-corpus of the mandible is located anteriorly, hence the general effects of jaw loading during speech will be during the production of anterior sounds [12]. This could be one reason for obtaining a statistically significant reduction of AMR of /pa/ in our study findings. Hence, anteriorly produced /pa/ is more affected than posteriorly produced /ta/ and /ka/.

Overall deduction in AMR values of /pa/, /ta/ and /ka/ in post mandibulectomy group suggest an abnormality of DDK rates indicating, an oral motor deficit that occurred due to oral

cancer resection of the mandible. This supports the finding of literature that revealed that reduced DDK can occur due to organic articulation defects. [11,2]

The change in SMR values across all control and clinical groups indicates that there is a change in speech motor functioning due to mandibular lesions as well as due to mandibulectomy. Studies have reported that change in speech motor functioning is reflected in changes in DDK values. [13] A reduced SMR value reflects reduced coordinated movement of lip, tongue, velum, and jaw. This reflects a deficiency in the temporal integration of speech structures during the sequential movement of articulators [14,3] in post mandibulectomy condition.

The values of syllable duration, peak intensity of CV syllable and inter syllable duration does not differ across control and clinical group. This finding was in agreement with literature which stated that the temporal regularity of DDK was not impaired due to mandibular lesions or mandibulectomy. [15]

Conclusion

The study was aimed at identifying the changes that occur in speech motor mechanisms in individuals with mandibular lesions and those who have undergone mandibulectomy surgery as compared to normals. The findings of the study revealed that the acoustic parameters of DDK, such as syllable duration, the peak intensity of CV syllable, and inter syllabic duration did not differ. These results indicate that influence of mandibular lesions and its surgical removal has only minimal influence on temporal parameters and intensity of single syllables.

However, the SMR rate among individuals who underwent mandibulectomy was found to be significantly reduced as compared to the normative group. Hence it can be concluded that the speech motor mechanism for coordinated movement of articulators was reduced significantly indicating there can be a delay in articulatory movements post mandibulectomy which can affect the speech production of individuals post mandibulectomy. This reflects that the mandibular stability is at risk for individuals post mandibulectomy.

The main strength of the study is that the speech motor coordination was studied by analyzing the intensity and temporal parameters of DDK. Another strength is that the study population included the same group of individuals before and after surgery, which revealed a relevant data on how the mandibular cancer lesions can affect the speech motor coordination. The limitation was that the affected population varied in terms of the type of lesions and type of surgery. This study opens the way for carrying out a similar study in a larger group of individuals who have similar lesions and have undergone a single type of mandibulectomy.

The clinical implications of the study are to incorporate DDK measurement in the daily practice of assessment of speech impairment in oral cancer patients. This will serve as a diagnostic index of speech impairment for detecting a change in speech motor functioning during the assessment of speech in oral cancer patients. This study also urges speech and swallowing pathologists to incorporate speech tasks for including speech motor coordination tasks while providing speech therapy to oral cancer patients for improving their speech motor control mechanism.

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References

1. Mosby, Inc. Mosby's medical dictionary. 8th ed. St. Louis, MO. 2009.
2. Heller KS, Levy J, Sciubba JJ. Speech patterns following partial glossectomy for small tumour of the tongue. Head & Neck.1991; 13: 340-343.
3. Fimbel, EJ, Domingo PP, Lamoureux, D & Beuter A. (2005). detection Automatic of movement disorders using recordings of rapid alternating movements. Journal of Neuroscience Methods, 146, 183– 190.
4. Fletcher, SG. The Fletcher Time-by-Count Test of Diadochokinetic Syllable Rate. Tigard, OR: C. C. Publ. 1978.
5. Gadesmann M, Miller, N. Reliability of speech diadochokinetic test measurement. Int. J. Lang. Comm. Dis. 2008; 43(1): 41–54.
6. Boersma P, Weenink, D. Praat: doing phonetics by computer [Computer program]. 2016
7. Baken RJ, Orlikoff RF. Clinical measurement of speech and voice. 2nd ed. San Diego: Singular Thomson Learning. 2000.
8. Mason, RM, Helmick, JW, Unger, JW, Gattozzi, JG, Murphy, MW. Speech screening of children in the dental office. Journal of American Dentist Association.1977; 94: 708–712.
9. Wang YT, Kent RD, Duffy JR, Thomas JE. Analysis of diadochokinesis in ataxic dysarthria using the motor speech profile program. Folia Phoniatrica et Logopaedica. 2009; 61: 1–11.
10. Westbury J, Dembowski JS. Articulatory kinematics of normal diadochokinetic performance. Annu Bull Res Inst Logop Phoniatr. 1993; 27:13–36.
11. Teichgraeber J, Bowman J, Goepfert H. New test series for the functional evaluation of oral cavity cancer. Head & Neck Surg. 1985; 8: 9-20.

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12. Daegling, JD. The Human Mandible and the Origins of Speech. Journal of Anthropology. 2012; 1-14.
13. Jothi, S. Amritha, ML. Comparison of Diadochokinetic Rate between Malayalam and Tamil Native Speakers. International Journal of Research & Review. 2019; 6(5): 2454-2237.
14. Yorkston KM, Beukelman DR, Strand E, Hakel, ME. Management of Motor Speech Disorders in Children and Adults. Austin, TX: Pro-Ed; 2010
15. Premalatha BS. Analysis of Articulatory and Resonatory Deviations in Glossectomees and Mandibulectomees. Unpublished Ph.D. thesis. National Institute of Mental Health and Neuro Sciences (Deemed University), Bangalore, India. 1998.

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APPENDIX – 1
Informed consent form

Name: Age/ Sex:
Address: Ph. No.
Address of the principal investigator:
Oral cancer is one of the most common cancers seen in India. The presence of cancer in the oral cavity can have an impact on speech production. Cancer on lower jaw can affect the speech clarity and integrity. We are helping you to deal with cancer and effect it can have on your life. Hence, we are studying the effect of cancer in the lower jaw as well as effect of surgery for removal of cancerous cell in lower and upper jaw in relation to speech production.

Your participation in the speech recording can help us to identify your speech characteristics that need improvement. This will also help us in counselling and providing effective speech therapy to you as well as to other patients. However, your participation does not affect your relation with the doctor or hospital. If you are willing to participate please fill in your name below and sign.

I,_____, the undersigned person having read and understood the study information sheet on my free will & volition give my informed consent to include myself / my family member in the study titled 'A cross-sectional study of comparing diadochokinesis parameters between normals and post mandibulectomy.

I have been explained about the need for the study in the language (Kannada) which I understand. I am aware about the tasks that I will have to perform for the study. I am also aware that I reserve my right to withdraw from this study at any stage. I understood that the assessment will be done free of cost and there will not be any compensation that will be provided for the same. I clearly understand that my recorded speech sample will be not be used for any other purpose other than the purpose mentioned above.

Signature of the participant Signature of the guardian

Signature of the investigator
Date: