COMPENSATORY STRATEGIES AND FEEDBACK OF HYOLARYNGEAL EXCURSION FOR SWALLOW IN TREATMENT OF SWALLOWING DIFFICULTIES IN PARKINSONS DISEASE: A CASE REPORT

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Abstract

Persons with Parkinson's disease present with symptoms of dysarthria and dysphagia as secondary motor symptoms of the disease (Jankovic, 2008). These symptoms are progressive in nature and require early identification and intervention. The oral and pharyngeal phases of swallowing are affected in the early or middle stages of the disease. Though evidences for various techniques of swallowing therapy exist in literature most clinicians use client oriented combination of techniques for improving the swallowing efficiency. This case report aims in providing evidence to the effectiveness of using a combination of compensatory strategies and feedback of hyolaryngeal excursion using digital acceleromery to improve swallowing efficiency in a client with Parkinson's plus syndrome. Training, transfer and generalization of treatment goals are also documented and discussed.

Keywords: *Deglutition, Dysphagia, Biofeedback, Accelerometry, Swallowing Disorders*

Introduction

Swallowing difficulty or dysphagia is a frequent problem reported in persons with Parkinson's disease (PD). The cardinal symptoms of PD is considered to be resting tremor, rigidity, loss of postural reflexes and bradykinesia which gradually progresses and leads to the secondary motor symptoms of dysarthria and dysphagia (Jankovic, 2008). Various stages of swallow could be affected leading to dysphagia, which could be at times seen even in the early stage of the disease.

The role of laryngeal elevation in protection of airway during the pharyngeal phase of swallow is well understood. Laryngeal elevation assists in airway closure and opening of upper oesophageal sphincter during normal swallowing. The laryngeal elevation should be coordinated with initiation of swallow at the end of oral phase and respiratory apnea at the beginning of pharyngeal phase and is associated with laryngeal closure preventing the bolus from entering the laryngeal lumen when it reaches the hypopharyngeal area. A failure in laryngeal elevation can lead to poorly protected airway and thus leading to high risk of aspiration (Logemann et al., 2000). Laryngeal elevation is associated with depression of hyoid bone and posterior movement of tongue during the final stages of oral phase of swallowing. Overall, movement of hyolaryngeal complex largely depends on tongue movements but the two functions can be independent of each other. In other words, the tongue can be moved posteriorly without initiation of swallow.

The structures that participate in speech also are a part of the swallowing system, and hence a deficit to these structures can affect the function of both these systems. A disordered swallow needs to be attended early because of its implications on the quality of life. But, although swallowing difficulties may emerge in the early or middle stages in a person with PD, they are usually untreated and neglected as there are other gross limitations which capture their attention during these stages. Therapy for swallowing difficulties is most effective if started early and effectiveness largely depends on various factors associated with the client and client's family such as severity of the disorder, cognitive status, intensity of therapy, family support and client motivation.

Persons with swallowing difficulties can be treated using compensatory approaches, indirect training or direct training (Logemann, 1984). Compensatory strategies involving postural and diet modifications do not directly affect the physiology of swallow but facilitates oral feeding. Indirect training includes techniques to train a client to perform certain exercises which improve certain processes of swallow such as lip closure, tongue movements etc. In this training, swallow function is not directly addressed. Contrary to the indirect swallow, in direct swallow training, various modifications are made so that the physiology of swallow is modified using for example, the swallow manoeuvres. Evidences for compensatory approaches, indirect and direct approaches exist in literature (Bhattacharya, Kotz & Shapiro, 2003; Blumenfeld, Hahn, Lepage, Leonard, & Belafsky, 2006; Bulow, Speyer,

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Baijens, Woisard, & Ekberg, 2008; Clave, De Kraa, Arreola, & Girvent, 2006; Hamdy, Jilani, Price, Parker, Hall & Power, 2003; Leelamanit, Limsakul, & Geater, 2002; Lewin, Hebert, Putnam, & DuBrow, 2001; Ludlow, Humbert, Saxon, Poletto, Sonies, & Crujido, 2007; Power et.al., 2006; Robbins et.al., 2008; Shaker, Easterling & Kern, 2002). However, most clinicians use a combination of these approaches for bringing the best results in swallowing therapy following detailed client oriented assessment and understanding of the swallowing function.

In addition to these approaches, different equipments have been used for swallowing therapy for providing a biofeedback to the client. Biofeedback, in general, has been studied for its efficacy in treatment of various disorders such as migraine headache (Medina, Diamond, & Franklin, 2005; Turin & Johnson, 1976), tension head ache (Holroyd et.al., 1984); gait training (Colborne, Olney, & Griffin, 1993; Ruth & Allan, 1980; Seeger, Caudrey, & Scholes, 1981), gastro-oesophageal reflux disorders (Shay et.al., 1986), articulation disorders (Bernhardt, Gick, Bacsfalvi, & Adler-Bock, 2005; Dagenais, 1995; Shawker & Barbara, 1985), cleft palate speech (Ysunza, Pamplona, Femat, Mayer, & Garćia-Velasco, 1997), dysarthric speech (Goldstein, Ziegler, Vogel, & Hoole, 1994) and in improving resonance after pharyngeal flap surgery for achieving velo-pharyngeal closure (Witzel, Tobe, & Salyier, 1989). It is a technique that has long been experimented in various skill training studies including swallowing because of its potential in providing real time information to the client as well as clinician about the performance. This facilitates motor learning in clients leading to a better functional outcome (Crary, Carnaby, Groher, & Helseth, 2004).

Swallowing is an automatic process in case of persons with normal swallow. Once disordered, relearning of this skill requires intensive training because of its serious implications. Crary et. al. (2004) described a structured biofeedback program using surface electromyography (sEMG) for clients with dysphagia following stroke and cancer of the head and neck in a retrospective analysis of their clients. Effectiveness of this therapy was more for clients with stroke than with head and neck cancer when functional outcomes were measured. Flexible video endoscopic procedure was also reported to be an effective biofeedback tool in rehabilitation after head and neck surgery (Denk & Kaider, 1997). These studies reported biofeedback as a cost and time effective program (Crary et.al., 2004; Denl & Kaider, 1997) and that biofeedback therapy significantly increased the chances of success and also limited the sessions spent on conventional therapy for functional outcomes (Denl & Kaider, 1997).

Biofeedback on hyolaryngeal excursion during swallow has not yet gathered much evidence. The procedure has been validated with simultaneous videofluroscopy and accelerometry recordings of swallow (Gupta et.al., 1995). Reddy et.al. (1996) correlated the amplitude of accelerometry recordings with the hyolaryngeal excursion during swallow. Reddy et.al. (2000) studied the effectiveness of biofeedback of hyolaryngeal excursion in the treatment of swallowing disorders and found consistent increase in amplitude of accelerometer recordings and improved functional outcomes. Their report was a compilation of five case reports of clients who had dysphagia secondary to various other disorders effectively rehabilitated using this procedure and is the only report available in this regard. This calls for a need for more evidence for this procedure for use with wider client population.

Evidence in the field of therapy for dysphagia is mostly gathered from case reports because of the heterogeneity in this clinical population. Cases act as their own controls in most of the therapy efficacy studies in dysphagia (Bryant, 1991; Reddy et.al., 1996; Reddy et.al., 2000). Though the evidence level through case studies is not high, they account for all the variables that may be present in a client. Multiple replications of similar methodology from multiple settings can be considered as a strong evidence for therapy efficacy.

In this regard, the present case study was aimed to generate evidence on a combination of biofeedback procedure applied on hyolaryngeal excursion along with compensatory strategies during swallow on a client with PD with frequent symptoms of aspiration. The digital accelerometry technique using the Digital Accelerometry for Swallowing Imaging (DASI^{TM} , Elixir Research) was used to record the hyolaryngeal excursion during assessment sessions and this technique was used as biofeedback tool in treatment of swallowing difficulty in this client.

Case report

A 77 year old Kannada speaking female reported to the Department of Clinical services of the All

India Institute of Speech and Hearing (AIISH), Mysore with speech and swallowing difficulties. The client complained of poor clarity of speech since three years. Swallowing difficulties were present since one year. Her diet was limited to semi solid and liquid. She needed support for all her daily living activities. Communication was mainly verbal, augmented with gestures. Medical history revealed a diagnosis of Parkinson's plus syndrome, Type 2 diabetes, essential hypertension, gastric ulcer, pedal oedema and obesity and was under medication for these associated problems. She was diagnosed with Parkinson's plus syndrome by a neurologist two years prior to the evaluation at AIISH and the client was in the middle stages of the PD (Score 3.0, Hoehn & Yahr scale, Hoehn & Yahr, 1967). She had also undergone Coronary Artery Bypass surgery one year back. Informal language assessment was carried out which revealed adequate comprehension and expression for daily conversation. A detailed speech, cognitive, sensory-motor, and swallowing evaluation were also carried out. The evaluations and its findings are detailed below:

1. ***Speech evaluation***
   Oral Mechanism Examination (OME) revealed normal structure of articulators. Movement of lips and tongue were slow but symmetrical. Diadochokinetic task was performed and alternate and sequential motion rate was 2 syllables/ second. However articulation was slow and slurred. Frenchay Dysarthria assessment (FDA, Enderby 1980) was also administered to assess the extent of problem in different speech structures. A diagnosis of hypokinetic dysarthria was made following the evaluation.

2. ***Cognitive/ psychological evaluation***
   The client or the family members did not report of any complaints on cognitive abilities of the client. However, on informal assessment some cognitive deficits were observed following which the Cognitive Linguistic Assessment Protocol in Kannada (CLAP-K, Kamath 2001) was administered. The results revealed mild cognitive deficits and the domain of memory were affected to a greater extent compared to other domains of CLAP-K.

3. **Sensory-motor evaluation**
   Detailed evaluation of sensory motor abilities by a physiotherapist reported rigidity in upper limbs, and bradykinesia. Observations made by physiotherapist also supported the diagnosis of hypokinetic dysarthria by speech-language pathologist.

Swallowing evaluation

4.1. *Behavioural assessment:* The Clinical Protocol for Assessment of Swallowing in Adults-Part B (Meerapriya & Manjula, 2009) was administered to identify the impaired stages of swallowing. The results revealed moderate impairment in the pharyngeal phase of swallow (Score1). Oral preparatory and oral stages of swallow were mildly impaired (Score 2).

4.2. *Instrumental assessment:* Boluses of varying consistency were used to evaluate the swallowing function: thin liquids (drinking water); solids (Idly mixed with Sambhar to a semi solid consistency). These items were selected based on the client's preference and availability. The efficiency of the dry swallow (saliva) was also evaluated. In the evaluation session no control over volume or consistency were placed by the clinician. The client was asked to feed herself with any of the solid/liquid items presented to her as she would normally do. An ideal meal session was simulated by presenting food in containers brought from the client's home. She was allowed to select the food item of her preference, in any order and in any volume.

Hyolaryngeal movements were recorded from the installation of the bolus to the client's mouth to complete swallow of the bolus using the Digital Accelerometry for Swallowing Imaging (DASI^{TM}, Elixir Research). The piezoelectric accelerometer sensor was placed on the hyolaryngeal complex and a neck collar was used to keep the sensor in place during the entire evaluation session. The instrumentation used, DASI^{TM} and placement of sensors are depicted in Figure 1.

The movement of the hyolaryngeal motion during swallow of saliva, liquid and solid bolus was recorded and displayed. The accelerometry recordings were analyzed later for wave morphology. The best waveforms obtained during the evaluation session have been shown in Figure 2a, Figure 2b and Figure 2c for dry, thin and thick bolus consistency respectively. A behavioural observation was also made during the entire process of ingestion to swallow and the findings have been depicted in Table 1.

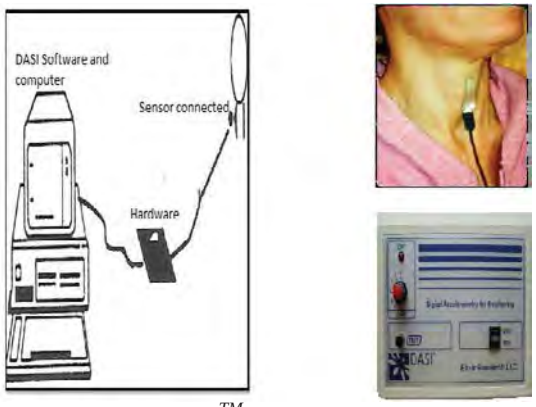

Figure 1. The DASI™ instrumentation that was used for providing biofeedback of hyolaryngeal motion. Photographs in the inset show the DASI™ hardware and placement of piezoelectric sensors on the thyroid angle of a client
(Source: http://www. Elixir research.com/dasi.html).

Table 1: Behavioural observations made during the simulated meal session before initiation of therapy.

Sl. No	Observations
1	Posture erect and appropriate
2	Preferred hands to spoon/fork
3	Preference for liquids than solids
4	Takes a large volume of bolus into mouth, much more than manageable.
5	Does not wait for complete swallow of food inside the mouth before ingestion of next bolus.
6	Reduced range of chewing for solid food item.
7	Tries to soak solids in saliva to soften them so as to compensate for the reduction in range of chewing.
8	Mashes the food between the tongue and hard palate especially towards the final chewing sequence.
9	Infrequent cough post swallow for all types of bolus.
10	Uses hands to push the solid bolus inside when the food becomes unmanageable with tongue.

From Figures 2a, 2b and 2c, the instability of hyolaryngeal complex before and after swallow could be observed for dry, liquid and solid bolus. Instability was more evident for dry and liquid bolus than solid bolus.

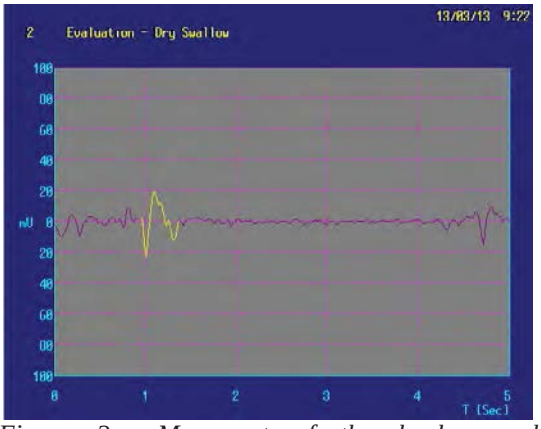

Figure 2a: Movement of the hyolaryngeal complex recorded using Digital Accelerometry during a trial on swallow of saliva (dry swallow). The yellow peak indicates swallowing event.

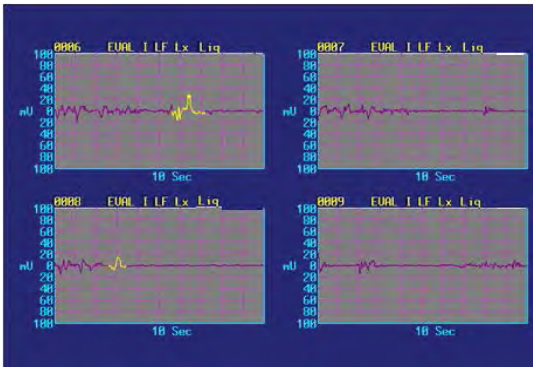

Figure 2b: Movement of the hyolaryngeal complex recorded using Digital Accelerometry during four different swallows of liquid bolus (water). The yellow peak indicates swallowing event.

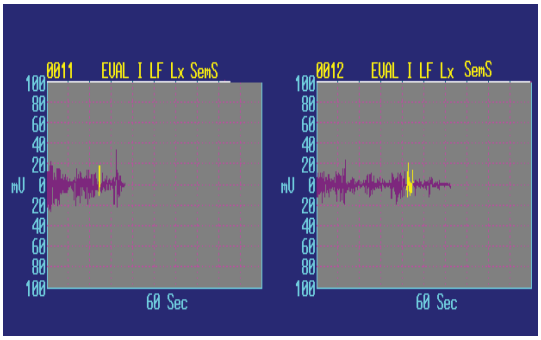

Figure 2c: Movement of the hyolaryngeal complex recorded using Digital Accelerometry during two swallows of solid bolus (swallow of Idly). The yellow peak indicates swallowing event.

For solid bolus the hyolaryngeal motion was associated with chewing and tongue movements before and after swallow but for swallow of liquid bolus the instability of hyolaryngeal motion could be associated with the movements of tongue in the attempt to control the flow of liquid inside the oral cavity. The tongue might need longer time to achieve its readiness for swallow of liquid bolus

than in case of dry swallow. The swallow of thin liquid and thick bolus was associated with occasional cough reflex post swallow.

The peak amplitude of each swallowing event recorded using digital accelerometry was obtained (Table 2). Consistent reduction in the amplitude parameters of these accelerometry recordings of hyo-laryngeal motion suggested rapid fatigue of swallowing system in this client. This information was helpful in deciding the duration of therapy session as 30 minutes with frequent breaks between each bolus swallow.

Table 2: Peak amplitude of swallow event recorded using Digital Accelerometry for various bolus consistencies in the assessment session

Bolus characteristics	Trial	Peak amplitude of swallowing event
Dry (saliva)	1	19
Liquids	1	28
	2	15
	3	No identifiable swallow
	4	No identifiable swallow
Solids (Idly)	1	21
	2	18

These observations indicated an immediate need for modification of swallow pattern. She was instructed to attend the swallowing therapy sessions (3sessions/wk) each lasting for 30 minutes. A total of 6 sessions were carried out to facilitate safe swallow of various bolus consistencies. The client also attended therapy for improving her speech, communication and cognitive abilities simultaneously. The following compensatory strategies were implemented during the swallowing therapy sessions:

1. Reduction in the volume of bolus placed inside the mouth for swallow
2. Modification of rate of ingestion and swallow such that there was a time interval between each swallow as required for the client.

These compensatory strategies were expected to facilitate safe swallowing. There was an indication for stabilizing the hyolaryngeal movements before and after swallow from the accelerometer recordings. This goal was worked upon using the biofeedback procedure for hyolaryngeal movement using digital accelerometry. The effectiveness of compensatory strategies and biofeedback therapy was assessed in terms of frequency of aspiration and client/ caregiver reported quality of feeding.

Digital accelerometry in swallowing therapy: The client and her caretaker were explained the physiology of normal swallow and the deviations in swallowing as observed in the client. The importance of adopting the compensatory strategies was also highlighted. The client was put on a biofeedback therapy for hyolaryngeal motion using Digital Accelerometry for Swallowing Imaging. The piezoelectric accelerometer sensor was placed on the hyolaryngeal complex and a neck collar was used to keep the sensor in place during the entire treatment session. The movement of the hyolaryngeal motion during swallow of saliva, liquid and solid bolus was recorded and displayed during each therapy session.

The client was trained to identify the swallow peak and the hyolaryngeal movements and to identify the stable and unstable hyolaryngeal activity. The client was explained to take two seconds before and after swallow to stabilize the hyolaryngeal complex. She was shown a diagrammatic representation of expected swallow pattern (Figure 3) which had a short time interval before and after swallow during which the hyolaryngeal complex was stabilized. The client was asked to mimic this pattern of swallow on the digital accelerometry during dry swallow. When the pattern could be reproduced in dry swallow, small volume of bolus was placed in the oral cavity for swallow.

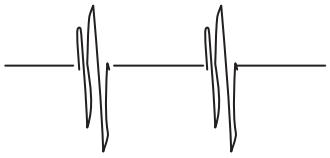

Figure 3 : Diagrammatic representation of an expected swallow pattern given to the client for imitation on the accelerometer recordings.

The sequence of bolus consistency followed was dry→ liquid→ semi solid→ solid. Though liquids were difficult to control in the oral cavity, it was thought to be best suited for initial stages of hyolaryngeal excursion biofeedback therapy as no chewing movements had to be associated with swallow and thus identification of correct and incorrect swallow pattern could be easily trained. Any symptoms of aspiration were noted in each type of bolus.

Results

The progression across sessions is described below.

Session 1: The client was asked to imitate the expected swallow pattern in dry swallow with an effort to stabilize the hyolaryngeal complex before and after swallow. Once the client could

achieve this expected swallow pattern (Figure 4), small amount of water (approximately 5ml) was given for swallow. The client was asked to maintain the pattern while swallowing the liquid bolus. Figure 5 shows the some of the accelerometry recordings obtained during swallow of thin liquids as the session progressed. There were no evident symptoms of aspiration with these modified swallow pattern. Also, the client had piece meal deglutition for 5 ml water indicating the client made an effort to incorporate the compensatory strategies advised at the beginning of the therapy session. Towards the end of the session, the client could identify the swallow peak 100% of the time without the help from the clinician.

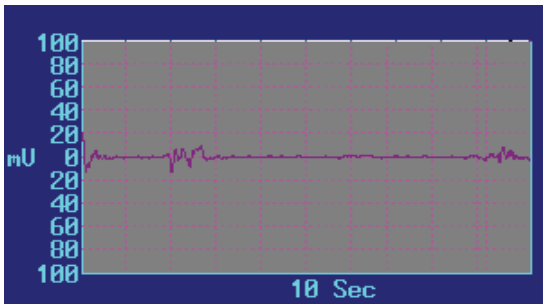

Figure 4: *Sample of the normal swallow pattern imitated by the client with the help of biofeedback information on hyolaryngeal excursion obtained through digital accelerometry during dry swallow.*

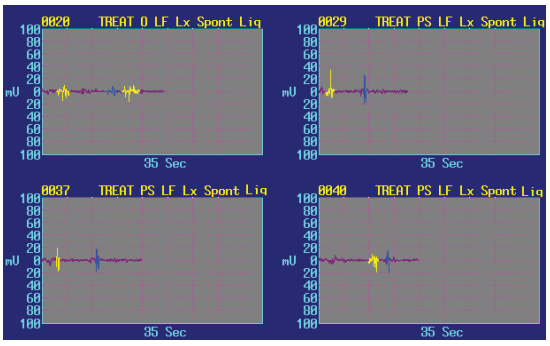

Figure 5: Samples of accelerometry recordings obtained as the session 1 progressed with swallow of thin liquids. The blue and yellow peaks indicate swallow.

Session 2&3: The client was made to practise producing the normal swallow pattern as in figure 3. After succeeding, the client was given 15 ml of thin liquid (orange juice) for swallow and she was asked to maintain the normal swallow pattern. Figure 6 shows the progression of therapy with swallow of thin liquids. The client adopted piece meal swallow for 15 ml thin liquids which was evident from the multiple swallows (blue &yellow peaks) in the accelerometry recordings. This indicated the clinician that the client was successfully incorporating the compensatory strategy. This also helped the client for a safe swallow with no symptoms of aspiration for swallow of larger volume of thin liquid. Towards the end of session 3, semisolid consistency (Idly - Sambhar) was introduced for swallow.

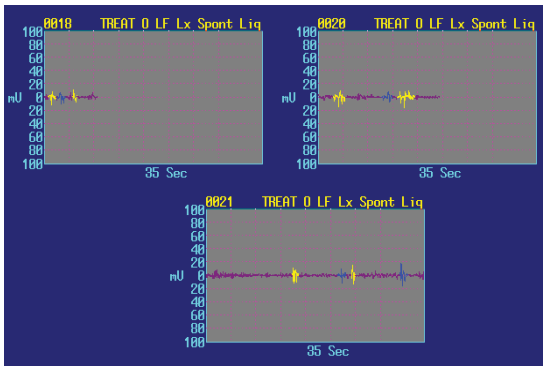

Figure 6: Samples of accelerometry recordings obtained as the session 2& 3 progressed with swallow of 15ml thin liquid (orange juice). The blue and yellow peaks indicate swallow.

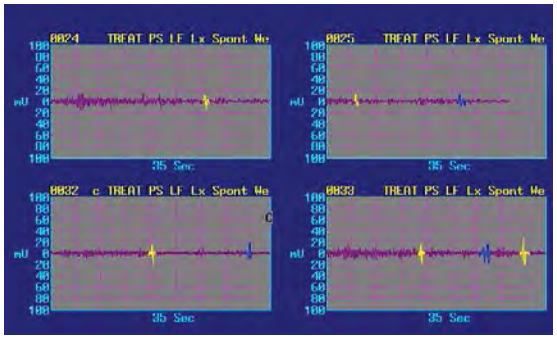

Figure 7: Samples of accelerometry recordings obtained as the session 2& 3 progressed with swallow of semisolid bolus (Idly- Sambhar). The cough reflex post swallow is indicated as 'C' in the recording 0032. The blue and yellow peaks indicate swallow.

Semi solids required some amount of chewing that made identification of swallow difficult. However, the client was asked to hold the food on the tongue and stabilize the hyo-laryngeal complex before and after swallow with feedback from accelerometry recordings. The swallow peaks had to be manually identified by the clinician. Progression of the session 3 with swallow of semisolid bolus is shown in figure 7.

There was only one instance of cough post swallow of semisolid bolus consistency. This is indicated as 'C' in figure 7. At the end of the third session, the client had oral intake of one glass of orange juice and one Idly-Sambhar without any evident symptoms of aspiration.

Session 4, 5 & 6: After practice of normal swallowing pattern in dry swallow (Figure 3), the client was provided with a plate of various items of varying consistency such as Idly- Sambhar, Biscuit and Dosa along with orange juice and drinking water. The client was given the freedom to select her bolus and to swallow them safe with the help of biofeedback from accelerometry recordings of hyolaryngeal movement.

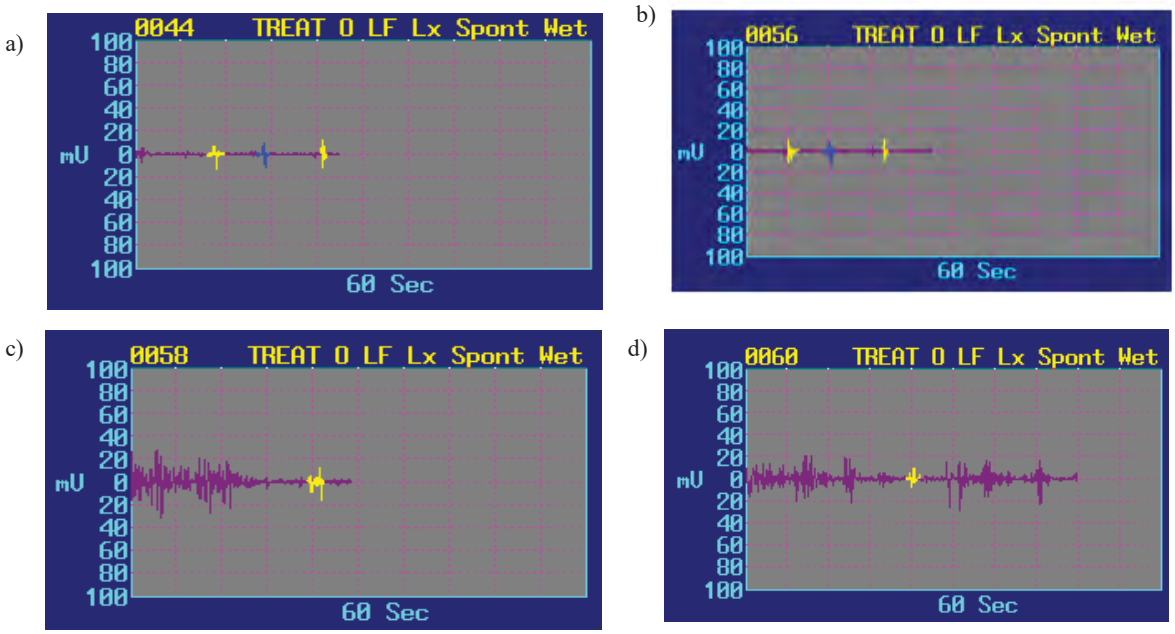

Figure 8 : Samples of accelerometry recordings obtained as the session 4,5& 6 progressed with swallow of (a) drinking water (b) Orange juice (c) Biscuit (d) Dosa. The blue and yellow peaks indicate swallow.

The consistency of biscuit bolus was different from the bolus consistencies given to the client in the previous sessions as the biscuit required hard continuous chewing than the semi-solid bolus. Rapid reduction in the range of chewing was observed and the clinician provided real time hand cue as visual feedback on range of chewing. There were breaks between each bolus intake to prevent fatigue of the swallow system. The best recordings during swallow of each bolus consistency are shown in figure 8.

The client could not complete her meal in the 4th and 5th session. At the end of the 6th session, the client could finish her meal orally with no evident symptoms of aspiration with the assistance of feedback of hyolaryngeal motion. The feedback was gradually restricted by turning the computer screen away from the client so that the client learns to incorporate the strategies in swallow without the help of digital accelerometry. The client was asked to attempt the same strategies during her meal times at home but under the supervision of her caretaker. They were asked to come back for therapy sessions if there were episodes of aspiration without biofeedback. Follow up was done after a week of withdrawal of therapy. The client and her family reported better quality of meal time and significantly lesser events of aspiration at home. Further enquiries revealed that aspiration persisted when the client had a quick meal.

Discussion

The present study reported the rehabilitation program implemented on a 77years female diagnosed with Parkinson's plus syndrome with complaints of swallowing difficulties. The client was trained on biofeedback therapy for hyolaryngeal excursion during swallowing of boluses of varying consistencies and volumes. The case report was intended to elaborate on the effectiveness of digital accelerometry in assessment of hyo-laryngeal excursion during the pharyngeal phase of swallow and its usefulness as a biofeedback tool when used along with compensatory strategies. Therapy outcomes were documented for every session as accelerometry recordings of laryngeal elevation during swallow.

Accelerometry recordings in the assessment session revealed instability of the hyolaryngeal complex before swallow. This instability was present for all bolus consistencies and volumes. This regular motion of hyolaryngeal complex gives an impression of tremor of hyolaryngeal musculature. This movement may also be recorded if there were tremors of tongue because the base of the tongue is indirectly connected to

hyoid bone and hyoid bone is connected to larynx. Since there were no evident tremors in the tongue, the instability of hyolaryngeal complex may be an indication of early involvement of external muscles of larynx in the Parkinson's plus syndromes. This is in support with the high incidence of vertical laryngeal tremors reported in Idiopathic Parkinson's clients by Perez, Ramig, Smith and Dromey (1996). However their study found higher incidence of arytenoid tremor in their clients with Parkinson's plus syndrome. The presence or absence of aretenoid tremor in this case with Parkinson's Plus syndrome could not be established physiologically; however a tremor in the voice was evident in this client. Early involvement of external muscle of larynx in PD was also reported in a study of laryngeal somatosensory function by Hammer and Burlow (2010). They explained Parkinson's disease as a disintegration of somatosensory control of the larynx. This study only hypothesized the sensory disintegration of laryngeal structure. The tremor like movements of hyolaryngeal complex recorded before swallow in the present case report suggested an early disintegration of sensory function in the extra laryngeal musculature. The presence of hyolaryngeal tremor before and after the client attempted swallow may indicate a kinetic or an action tremor rather than a passive tremor that is usually seen in persons with PD. The usefulness of accelerometry in assessment of laryngeal tremor is indicated but needs further research.

Effectiveness of biofeedback therapy has a long history in studies using surface electromyography. Crary (1995) reported the improvements in six clients with brainstem stroke treated with sEMG biofeedback. This report also mentioned the long term maintenance of relearned swallowing in their clients. Based on the findings of accelerometry, therapy was initiated for this client using hyolaryngeal excursion as biofeedback to modify the swallow pattern. The client was trained to identify swallow peaks and to discriminate between correct and incorrect swallow patterns. The progression of this client within and across sessions for swallow of varying consistency and volume of bolus were inspiring. However, effectiveness of therapy can be attributed to the compensatory strategies adopted as well as the biofeedback procedure followed. Such combination of approaches is frequently indicated in routine clinical practice (Logemann, Gesler, Robbins, Lindblad, Hind, & Kosek, 2008)

A similar study was conducted by Reddy et.al. (2000) in which they detailed six cases enrolled in biofeedback therapy using a similar non-invasive accelerometry procedure. In the case series reported by Reddy et.al. (2000), the focus was on improving the amplitude measures of hyolaryngeal excursion because increased hyolaryngeal excursion leads to increased amplitude of accelerometer recordings. However, various factors such as thickness of skin on the neck and skin resistance can dampen the amplitude measures of accelerometer recordings. A low amplitude accelerometer recording may or may not indicate a poor laryngeal elevation. But there are lesser chances of durational measures and pattern of swallow getting affected by these variables and thus temporal parameters and morphology of accelerometer recording may provide more useful information than amplitude measures. It is the author's observation that men generally have a high amplitude accelerometer recording than women which may be due to the prominent thyroid angle and lesser fat under the skin on the surface of the neck for male population.

The present study also indicated that swallowing is a skill that can be relearned. The client has learned to control her laryngeal instability before and after swallow of bolus leading to a safer swallow than pre-therapy. The pharyngeal phase characterized by its involuntary control mechanisms seems to constitute of certain functions that can be brought under voluntary control such as the hyolaryngeal stability before and after swallow. This relearning of swallow is the basis for success in rehabilitation of persons with swallowing disorders. However, there are a number of pre-requisites for success of swallowing therapy such as the cognitive status of the client, motivation, family support etc. In this client, bio feedback therapy proved effective probably because of her cognitive abilities were only mildly impaired. Thus the results of this study cannot be generalized and has to be understood with caution because the same technique may not work with all clients with pharyngeal phase deficits.

Swallowing is a highly heterogeneous function with no clear boundaries between the normal and abnormal. The interpersonal and intrapersonal variability in normal swallow makes generalization inappropriate. The field of dysphagia has been concentrating on case studies and case series rather than group generalizations. This study is a contribution to the existing literature on effectiveness of biofeedback in swallowing skill training when combined with some compensatory strategies. Though biofeedback is a commonly used non invasive technique which is easily available in various forms to clinicians all over the world, the number of published data in this field remains scarce. The

available data are not uniform in its methodology. There is a need to understand the factors that determine the efficacy of biofeedback procedures on clients with swallowing difficulty and the parameters that signify appropriate hyolaryngeal elevation for safe swallow. Future studies should focus on identification of predictors of laryngeal elevation in accelerometry recordings so that the procedure may be applied on the most suitable candidates. Also, there is a need to understand the effectiveness of various approaches when applied in combination because in practical situations a combination of strategies is most commonly required for rehabilitation of clients with swallowing disorders.

Conclusion

This study was carried out on a client diagnosed with Parkinson plus syndrome with symptoms of aspiration. The client also had associated speech related issues. Cognitive status was mildly impaired but was appropriate for daily activities. Detailed speech, cognition and swallowing evaluations were carried out. Swallowing evaluation using digital accelerometry revealed unstable hyolaryngeal complex before and after swallow for all bolus consistencies. Cough reflex was associated with swallow of thin (liquid) and thick (solid) bolus. The client was trained on an intensive biofeedback therapy using digital accelerometry for stabilising the hyolaryngeal excursion before and after swallow of various consistencies of bolus. Compensatory strategies were also warranted. The client made consistent and rapid progress when compensatory strategies were used in combination with biofeedback therapy for hyolaryngeal excursion. By the end of 6^{th} session with biofeedback, the client was able to manage oral feeding with significantly lesser instances of aspiration. After one week of discharge from the therapy, the client was able to maintain the strategies and was enjoying a safe meal time with her family.

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