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Efficacy of the Test of Mastication & Swallowing Solids (TOMASS) in Mild-to-Moderate Dysphagia: A Review

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ABSTRACT

Background: *Dysphagia is a sign of psychological or neurological disease and is a major social health issue. Due to its great frequency and serious effects, it has recently received much attention. Since 2014, TOMASS has been acknowledged and utilised as an evaluation technique for masticatory efficiency alongside many other assessment methods. However, due to the lack of normative data to back it up, its therapeutic applicability and efficacy still need to be debated in several areas.*

Objective: *To review the evidence and literature available on the efficacy of TOMASS (the Test of Masticating and Swallowing Solids) for patients with dysphagia, mainly in the oral phase. This review article aims to investigate (1) the efficacy of TOMASS for mild-to-moderate dysphagia in the clinical setting and (2) the identification of the barriers and factors influencing masticatory efficiency while administering TOMASS.*

Method: *A systematic literature search was conducted through several databases, including PubMed, the Lancet, Google Scholar, MEDLINE, and Sci-Hub, to find the most relevant research about the efficacy of TOMASS published in different journals from 2017 to 2022. All the connected papers' findings were examined and analysed for similarity and deviation.*

Conclusion: *The efficacy of the TOMASS for the chewing function in patients with mild-to-moderate dysphagia should be included as an auxiliary to other qualitative assessment methods in a clinical and online setting, according to the literature review. Additionally, when administering TOMASS, the type of crackers, sex, age, and degree of disorder should be considered. Finally, it is critical to develop a clinically valid, reliable protocol specific to the communal reference data to serve as a clinical benchmark for assessing masticatory effectiveness.*

Keywords: *mastication; clinical assessment; chewing; swallowing; quantitative; objective; TOMASS; dysphagia*

I. INTRODUCTION

Dysphagia is when a food bolus moves atypically slowly from the oropharynx to the stomach (Abdel et al., 2015). Various underlying illnesses, including head and neck cancer, stroke, and neurological conditions, can cause oropharyngeal dysphagia. It significantly impacts health-related quality of life (Jones et al., 2018). Oral (preparatory), oropharyngeal (transfer), and oesophagal phases make up the swallowing process (Chilukuri, 2018). Dysphagia can lead to aspiration pneumonia, dehydration, malnutrition, and even death (Baijens et al., 2021). Dysphagia prevalence estimates for the general population range from 2.3% to 16% (Kertscher et al., 2015). However, they can reach up to 80% in patients with Parkinson's and stroke and around 90% in individuals with pneumonia. According to meta-analyses used to estimate the prevalence of dysphagia

in various healthcare settings, the figures are hospitals (36.5%), rehabilitation institutes (42.5%), and nursing homes (50.2%) (Rivelsrud et al., 2022).

The oral stage of swallowing is a complex blend of events. The two primary steps in the oral cavity are oral preparatory and oral propulsive, and their order is firmly linked with the pharyngeal phase of swallowing. The potential for direct observation of the oral events enables accurate reconstruction of the complete swallowing act and a better understanding of the pharyngeal activities. Because of this, a videofluoroscopic study (VFSS) has historically been regarded as the gold standard for instruments (Farneti, 2014). However, the contrast between impaired and unimpaired functioning may be difficult to see in patients with less prominent clinical presentations. As a result, chewing-related protein-energy malnutrition in children is overlooked in the elderly population (Sheiham, 2001). Moreover, the elderly population tend to misrepresent their performance. If normative values were readily available for comparison, clinical metrics that are quantitative and verifiable would likely boost clinical validity and administrative purpose (Huckabee, 2018).

Mastication is an essential part of the swallowing process (Peyron et al., 2017), which requires oral structures' integrity and neuromuscular control within normal limits (van der Bilt, 2011). Proper mastication and swallow readiness are crucial to preventing choking (Steele & Matsuo, 2019). The objectives of mastication include breaking up food to increase surface area and combining the meal with saliva to create a bolus that is swallowed safely. In addition to these functional features, mastication also has significant psychosocial functions, particularly as individuals age and eating becomes one of life's main pleasures (Müller, 2013). Standard jaw, tooth, and salivary functions, and proper muscle control of chewing muscles & tongue are necessary to produce a solid bolus that may be carefully ingested (van der Bilt, 2011). Several masticatory metrics, including the number of chewing cycles, the chewing rate (number of cycles per second), the length of the order, muscular activity, and the dimension and shapes of mandibular movements, can be used to define the motor work of mastication (Peyron et al., 2017).

Gisel and colleagues documented changes in development and gendered variations in factors associated with oral consumption of various bolus categories in children aged two to eight years in several investigations. They proposed the accuracy of the measured "time" (per bite) and "masticatory cycles" according to this age group, and observed a decline in "time" and "masticatory cycles" with ageing and greater "time/cycle ratios" in their female subjects. Conversely, statistics are unavailable for kids and teenagers above eight years of age.

Several readings have investigated efficient masticatory constraints in small control populations. Hiiemae et al. (1996) observed that, depending on the food texture, the entire masticatory cycle for one bite ranged from 17.58s to 24.47s, with the average masticatory sequence lasting from 0.58 to 0.82s. Hiiemae and Palmer (1999) replicated similar findings in a subsequent investigation involving ten individuals, showing that it took an average of 22.8 seconds to consume an 8g taster of peanuts and 23.61 seconds to eat a similar bulk trial of shortbread.

Palmer et al. (2007) discovered a similar result: it took an average of 19.6 seconds for eight individuals, with an average age of 23 years, to ingest an 8g piece of shortbread. They swallowed twice throughout this period and completed 23 masticatory cycles, with an average time of 0.76 seconds for each process. These studies do not highlight the deficiency of widespread norms stratified by the impact of age and sexual orientation that can be considered clinically in the assessment of dysphagia, even though they begin to fix a breach in the literature (Huckabee et al., 2017). The "Test of Masticating and Swallowing Solids" (TOMASS) was created as an objective tool of assessment to determine oral pharyngeal effectiveness for solid bolus consumption to address this (Athukorala et al., 2014).

Usually, qualitative observations of mastication are administered to evaluate patients' swallowing, and SLPs write comments on what they see. A crucial aspect of the clinical swallowing examination is the observation of oral intake (trial swallows). Although speech-language therapists use a range of bolus textures, only the addition of liquids is supported by research (McCullough, Wertz, Rosenbek, & Dinneen, 1999). The oral phase of eating, notably chewing and the preparation of bolus, needs to be sufficiently addressed by alternating thin and thick liquids.

The Timed Water Swallowing Test (TWST) is a tool for quantifiable assessment & documentation of the water intake using the same method (Hughes & Wiles, 1996). TWST is an evaluation of the oropharyngeal phase of swallowing on 100–150 mL of water that offers precise, quantitative data (such as the quantity of swallows, the overall time required, and any salivating, voice fluctuations, or coughing) (Sophie et al., 2021). TOMASS, adapted from TWST, was developed in 2014, incorporating solid bolus to assess the masticatory efficiency. The test parameters, material, and methods for pediatric and elderly populations were the same. The material included a stopwatch, crackers, a video recorder, and a cup of water just in case of a dry mouth. So far, the crackers used in the studies were similar in size, weight, perceptual traits, and ingredients (Frank et al., 2019).

The procedure required an individual to sit and eat the cracker as comfortably fast as possible. The cracker division was permitted only by the teeth and lips (Hägglund et al., 2020). Upon swallowing the cracker completely, an individual was asked to say their name loudly as the last step of the test and to clear the oral cavity (Veld et al., 2020). The four parameters for TOMASS included the number of bites, chews, swallows, and ingestion time recorded for a single cracker. The number of cracker pieces each participant put in their mouth to make up a bite was recorded. Only the lips or teeth were permitted to divide the cracker. The number of chews refers to the jaw movement, particularly upward and downward; the number of swallows refers to the superior activity of the thyroid cartilage, and ingestion time starts from the individual's lips to the time when they say their name after finishing the cracker (Kristin L. G. et al., 2018). The scores are supposed to be compared with normative data available from previous research studies.

The masticatory ability of individuals with dysphagia has been evaluated in several ways up until this point. The patients typically assess the masticatory function subjectively using questionnaires and interviews. Subjective tests include measures of self-satisfaction with chewing ability in everyday life, such as the Food Index Ability (FIA), the Visual Analogue Scale (VAS), etc. In comparison, objective evaluation techniques examine the masticatory strength, the movement of the masticatory muscle, and masticatory competence. The literature claimed some, like the 6-Minute Mastication Test, ViewGum, the Mixing Ability Index (MAI), the Oral Fiberoptic Endoscopic Evaluation of Swallowing (O-FEES), etc. (Ahn et al., 2010). This review study aims to determine how well TOMASS measures the masticatory functions of individuals with mild to moderate dysphagia.

II. DISCUSSION

The TOMASS is a reasonably recent quantifiable technique for assessing bolus swallowing and masticatory function. To differentiate between typical swallowing of solid consistency and poor consumption that may specify a malfunction, speech-language pathologists need reliable normative data on the crackers utilized in their clinical setting. The current review article aims to determine the efficacy of TOMASS in a daily assessment of dysphagia, mainly mastication. However, some factors to implement this test in the clinical setting should be considered, like the type of crackers, age, sex, and degree of swallowing concerns. In addition, the effectiveness of this objective exam needs to be established due to the need for more research on TOMASS in general.

Crackers Parameter

With 80 to 285 volunteers for each cracker type, the 2018 experiment included seven distinct types of crackers from North America, Portugal/Italy, Germany, the UK/Ireland, the Netherlands, New Zealand/Australia, and Israel. The authors claim that the consumed cracker affected the findings of several masticatory parameters assessed during TOMASS. In a study involving 234 healthy volunteers, there were no appreciable differences between the crackers (Tuc versus Guld Marie) for the first part, which was the choice of crackers. The Guld Marie cracker took more descriptive chewing rounds than the Tuc cracker, even though the dissimilarities were not of any statistical significance ($p = 0.06$; $F = 7.1$). On average, finishing the Guld Marie cracker required longer on average to consume than the Tuc (36.3 versus 33.4s). These variations were

not statistically significant in any case. According to studies from 2017 to 2021, variations in patients' ability to masticate were caused by the amount of fat and other ingredients in the crackers.

Age & Sex Parameter

Hagglund et al. discovered in a study conducted in 2021 that older individuals chewed crackers on average more frequently and for a more extended time than younger participants. Furthermore, older participants needed more bites of the Guld Marie cracker than younger participants. Although the effect did not achieve statistical significance, the elderly individuals who took the Tuc cracker exhibited a similar pattern. There were no discernible variations between older and younger participants in the number of swallows necessary to finish the crackers. The TOMASS's bite count (n = 292, p = 0.009, r = 0.15), chewing cycle (n = 291, p 0.0001, r = 0.33), and duration (n = 292, p 0.0001, r = 0.32) were all positively connected with age, according to a 2022 study by Oshrat. Furthermore, in TOMASS, females required more swallows, bites, chewing cycles, and duration than males.

These results align with earlier studies (Feldman, Kapur, Alman, & Chauncey, 1980; Peyron et al., 2004, 2017; van der Bilt, 2011; Woda et al., 2006). Therefore, it is crucial to remember that the quantifiable TOMASS results for adult participants should be regarded as something other than a sign of poorer masticatory quality. The ageing impact on chewing behaviours is more consistent with the influence of ageing on swallowing. According to the literature, healthy individuals' swallowing ability declines with age (Wiles, Nathadwarawala, Nicklin, 1992; Wiles & Hughes, 1996) primarily because of a naturally declining functional reserve. Despite this, the bolus is transported safely and effectively from the oral cavity to the digestive tract (Baijens et al., 2016; Hughes & Wiles, 1996; Nathadwarawala et al.). Thus, despite physiologic changes brought on by ageing, the masticating functions are necessary for appropriately preparing and delivering the swallowed bolus (Hagglund, 2021).

Administrative Protocols

TOMASS is an easy, free-of-cost, time-effective, non-invasive, and advantageous objective assessment tool for the oral phase (O. Apperley et al., 2017) and later stages of swallowing during bedside evaluation (Huckabee et al., 2018) with only one material: cracker. The masticatory sequences, number of bites, and swallows must be counted clinically; however, these observations are highly linked with instrumental measures of the same behaviour. As a result, measurements taken at the patient's bedside can provide insight into their ability to chew and swallow without using instruments (Huckabee, 2017). This test also has robust test-retest reliability & comparable normative data for every age bracket from four years onwards (Huckabee et al., 2018). Not only the healthy population, but this test is also meaningful for people with Parkinson's disease (R.P. Athukorala et al., 2014) and for those who present with hypotonia like Down syndrome at 3-year-stage receptive language abilities to see the efficacy of recommended chewing exercises (W. J. A. in't Veld et al, 2020). This test can be used to document the progress in the outpatient clinical setting (Huckabee, 2020) and over teletherapy after receiving proper training to administer this test accurately (*Wan*-Tia, 2015), which is vital in the wake of the pandemic these days.

With many strengths, TOMASS has numerous limitations as well. The normative data lack standardized scores; it only tells how fast an individual can eat (Huckabee, 2020) but cannot distinguish between normal versus impaired masticatory performances (Hägglund et al., 2020). This test can be difficult to administer to those with severe-to-profound dysphagia who lack swallow readiness (Steele & Matsuo, 2019), as most studies are done on patients with mild-to-moderate swallowing concerns (*Wan*-Tia, 2015) or healthy individuals. Moreover, this test cannot be used in the acute care setting as the response from profoundly ill patients to TOMASS was not satisfying, including those with head & neck cancers (Huckabee, 2020). Additionally, there is a lack of evidence on how this test can detect pharyngeal pressure, pathophysiology, UES functioning (Huckabee, 2020), & transition/generalization from a cracker to other foods.

Clinical Implications

In general, speech and language pathologists need to be aware of this test and locally available crackers that can be used, as the research on TOMASS could be more extensive. Out of all the crackers used in various studies related to TOMASS from 2018 to 2022, the German de Beukelaer TUC Classic™ and Indian TUC biscuit seem similar in size, weight, and physical qualities. The literature also claimed that TOMASS is a practical test to evaluate patients' chewing in clinical settings and during teletherapy sessions.

Moreover, there are some essential factors that an SLP should consider while judging the scores. For children on TOMASS-C, the number of bites, chews, and total eating time may vary as a part of masticatory development. However, the number of swallows remains the same for younger and older children (Frank et al., 2018). TOMASS-C can be challenging in case of behavioural concerns, excessive drooling, and inability to follow instructions, oral residue, or other functional/anatomical considerations (O. Apperley et al., 2017). For use in younger patients with swallowing issues, several studies advise combining the TOMASS with other quantifiable mastication tests, such as the 6-Minute Mastication Test or the Karaduman Chewing Performance Scale, to assess mastication endurance (Frank et al., 2018). Furthermore, it is recommended to consider only those participants who can be benefitted from this test.

For adults on TOMASS, the number of swallows is the same for older and younger adults; however, the quantity of bites, chews, and total time is increased in older adults than younger adults (Peyron et al., 2017). Regarding sex, males take bigger and fewer bites along with a smaller number of chews resulting in a shorter amount of time than females (P. Hagglund et al., 2020; Magie-Lee Huckabee et al., 2017). Other factors like height-based hyoid excursion (Molfenter & Steele, 2013), dentition/occlusion, tongue pressure (Engel-Hoek et al., 2012), sensory input (Miller & Steele, 2010), perceptual features of a cracker (Hägglund et al., 2020), dry mouth, motivation, and affective behaviour may also affect the masticatory efficiency (O. Apperley et al., 2017). Moreover, the number of swallows will be challenging to see in patients with submental fullness; however, due to the tactile nature of assessment, i.e., four-finger-test, may help in such cases.

Lastly, any test that measures chewing efficiency solely on a technical level only discloses a few facets of the complicated chewing behaviour. A thorough analysis of the masticatory process should preferably include an objective assessment and qualitative data on any potential physiological compensatory mechanisms, such as lengthening the time spent chewing, increasing the number of chewing cycles before swallowing, or even engaging in food avoidance. Dysphagia of the oral phase must be considered to have impaired chewing efficiency; therefore, swallowing difficulties may also be linked to the outcomes (Schimmel, 2015).

III. CONCLUSION

It is possible to characterise the TOMASS implementation because it is only effective and efficient when used in conjunction with other assessment approaches for the evaluation of mild to moderate dysphagia. Since TOMASS reliability in isolation has received little research attention, it still needs to be used in SLPs' clinical practice. Due to this, it is crucial to design a method that is clinically valid, reliable, and unique to the communal reference data to serve as a clinical benchmark for evaluating masticatory efficiency within the community. Hence, a blend of quantitative and qualitative procedures for individualised & holistic goals of care, in terms of chewing efficiency for patients with mild-to-moderate dysphagia, is recommended.

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