

ASSESSMENT OF INTRA AND INTER- EXAMINER RELIABILITY FOR PROPOSED SCALE OF MASTICATION IN CHILDREN– A PRELIMINARY STUDY

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ABSTRACT

Aim: The aim of this study was to validate a method for assessment of mastication in children.

Methods: A video-based method is used for the assessment of mastication in children. Assessment parameters include bilateral and cyclic chewing, cutting ability and bolus formation. A sample of 10 children was selected in the age group of 6-12-year-old whose video of carrot chewing was recorded by a parent in a manner explained to them. Two examiners independently assessed the videos for the purpose of validation.

Results: The bilateral and cyclic chewing had 100% of level of agreement while cutting ability and bolus formation had 38% and 46% of agreement respectively using kappa statistics.

Conclusion: The proposed scale of mastication will require further validation pertaining to video standardization and prior consensus on the working definitions.

KEYWORDS: mastication, assessment, children, validity, reliability, bilateral chewing, cyclic chewing, cutting ability, bolus formation

INTRODUCTION

“Mastication efficiency is defined as the efficiency of crushing food between the teeth and manipulating the resulting particles to form a swallowable food bolus.” Precisely speaking, ‘to masticate’ is to grind and pulverize food inside the mouth, using the teeth and jaws, this definition is extended here to the action of forming a swallowable food bolus, even if it is prepared by the mechanical action of the gums and tongue or the enzymatic action of saliva.^[1]

It is a skill developed with growth; babies begin to develop this skill at the age of 6 months and attain most of the necessary coordinated movements by 9 months.^[2]

Mastication is the most initial step for food ingestion, but it is especially important for many fruits and raw vegetables because they have indigestible cellulose membranes that must be broken before the food can be digested. This process is carried by coordinated action of the teeth, the jaw muscles, the temporomandibular joints, the tongue, the cheeks and the lips.^[3]

Not only does it affect digestion, absorption, and metabolism of food, but also it has implications in jaw growth. It is under the control of the central pattern generator located in the

brain stem. The mechanical breakage of foods makes enzymatic processing easier in the digestive system, since this mechanism is influenced by the way that foods are chewed. ^[4]

Mastication is a developmental function and its maturation occurs from learning experiences. If adequate, it provides stimulus and proper function to the normal development of the maxilla and mandible. Several studies have indicated that impaired chewing ability affects the nutrient intake subsequently worsening the nutritional status and as a result affecting the general health status of the people. ^[5]

All the components: bones, muscles, teeth and soft tissues assist in chewing. The normal growth of bones is important as they provide more space for eruption of teeth. The proper eruption of teeth results in good occlusion which leads to efficient mastication and thus improving overall nutritional value. Soft tissues in the oral cavity, such as tongue, lips and cheeks affect the masticatory performance. Adequate tongue pressure is required for the efficient chewing. All of the above-mentioned components of mastication are subject to a range of changes during the phases of growth. Chewing of food starts during the second half of the year of life and continues to develop till childhood. ^[6]

Till 4-6 months, infants are fed with only liquids and then solid foods are fed which helps in developing oral-motor skills. Hard and solid foods are necessary to develop overall jaw growth of children. It has been observed that soft diet retards the growth of mandible in animal and also results in weak musculature. Thus, the importance of inculcating proper chewing habits needs to be overemphasized. However, there is limited literature available on assessing and improving mastication in children with interventions in the Indian context. Chewing of carrots, peanuts and similar hard food items can help develop mastication; these items have been used as interventions in several studies. ^[7]

Many clinical assessment methods were developed to assess masticatory performance, for example, color changing chewing gums, sieving comminuted food or artificial food, optical scanning of masticated particles, or measuring release of dye when chewing food. Currently, there are many different methods used to clinically assess masticatory performance objectively (here, performance refers to someone's objective ability to mix or comminute food bolus) But no method can be recommended for use in dental operatory and scientific environments as it lacks reliability, validity and ease of use. ^[8]

For practitioners and researchers, it would be interesting to find out if a method could be used to evaluate masticatory ability before dental treatment

OBJECTIVES

1. To assess the intra examiner variability
2. To assess the inter examiner variability

METHODOLOGY

The study was planned in the Department of Pediatric and Preventive Dentistry, Bharti Vidyapeeth (Deemed to be University) Dental College and Hospital (BVDUDCH), Navi Mumbai. The study was approved by the Scientific Research Committee (SRC) and the Institutional Review Board (IRB) of BVDUDCH. The independent variable of the study was carrot chewing while dependent variables were the masticatory performance which includes bilateral and cyclic chewing, cutting ability, and bolus formation.

Inclusion criteria

- Children in the age group 6-12 year (mixed dentition period) who are otherwise healthy.

Exclusion criteria

- Children with any food allergies and restrictions.
- Children having any immunocompromised state or medically compromised.
- Children with teeth damaged to that extent where normal chewing is affected.
- Children undergoing orthodontic treatment.

A sample of 10 healthy children in the age group of 6-12-year-old was selected. After recruitment all the children were assessed for mastication. A video recording of the child chewing carrot was done by a parent in a manner explained to them.

The baseline assessment of participants was made using four parameter scale:

1. Bilateral chewing
2. Cyclic chewing
3. Cutting ability
4. Bolus formation

The following working definitions used for the assessment of mastication shown in table 1.

Table 1

BILATERAL CHEWING	The effort required to achieve a standard degree of comminution of carrot which is performed bilaterally and simultaneously. ^{[8] [9]}
CYCLIC CHEWING	Mastication is characterized by cyclic jaw movements in three dimensions (vertical, lateral, and anteroposterior), and less rigid facial and tongue motility patterns. These various movements are produced by the coordinated contraction of the jaw, face, and tongue muscles. ^{[8] [9]}
CUTTING ABILITY	The ability to cut carrot into small pieces.

BOLUS FORMATION	The aggregation of finely cut particles of carrot which is formed by folding and manipulating food particles with the tongue.
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In order to assist the mastication, the child was asked to sit in the comfortable position on a chair then carrot was offered to the child. After a few chewing cycles the assessor recorded a video of the mastication. The mastication cycles begin with cutting a carrot and chewing it until the swallow and then child was asked to open the mouth once before swallowing to show the bolus. Two examiners independently assessed the videos for the purpose of validation. The agreements pertaining to each of the parameters is statistically analyzed and reported.

STATISTICAL ANALYSIS

The Cohen's kappa statistics was used for measuring the agreement between examiners. To interpret Cohen's kappa results, following guidelines (see Landis, JR & Koch, GG (1977) was used. The measurement of observer agreement for categorical data. Biometrics, 33, 159-174):

1. 0.01 – 0.20 slight agreement
2. 0.21 – 0.40 fair agreement
3. 0.41 – 0.60 moderate agreement
4. 0.61 – 0.80 substantial agreement
5. 0.81 – 1.00 almost perfect or perfect agreement

RESULTS

The proposed masticatory assessment scale has four parameters which include bilateral chewing, cyclic chewing, cutting ability and bolus formation. A total of 10 videos of children chewing carrot was evaluated by three examiners (two residents and one professor from the Department of Pediatric and Preventive dentistry).

Table 2 and table 3 shows the Intra-examiner score sheet, who assessed and scored in a time interval of two months. Table 5 and table 6 shows the inter-examiner score sheet of examiner one and examiner two respectively.

Intra examiner, 100% and 76% percent of agreement was found in cutting ability and bolus formation respectively. Bilateral and cyclic chewing was 96% and 92% of agreement respectively [shown in table 4].

In inter-examiner, 100% of agreement was found in bilateral and cyclic chewing chewing. Cutting ability and bolus formation was 46% and 38% respectively [shown in table 7].

Table 2

Parameters	Bilateral	Cyclic	Cutting	Bolus
Video 1	Yes/No	Yes	Yes	Yes
Video 2	Yes	Yes/No	Yes	Yes
Video 3	Yes	Yes	Yes/No	Yes
Video 4	Yes	Yes	Yes	Yes
Video 5	Yes/No	Yes	yes	Yes/No
Video 6	Yes	Yes	Yes	Yes
Video 7	Yes	Yes	Yes	Yes
Video 8	Yes	Yes	Yes	Yes

Table 3

Parameters	Bilateral	Cyclic	Cutting	Bolus
Video 1	Yes	Yes	Yes	Yes
Video 2	Yes	No	Yes	Yes
Video 3	Yes	Yes/No	Yes/No	Yes/No
Video 4	Yes	Yes	Yes	Yes
Video 5	Yes/No	Yes	yes	Yes/No
Video 6	Yes	Yes	Yes	Yes
Video 7	Yes	Yes	Yes	Yes
Video 8	Yes	Yes	Yes	Yes

Table 4

PARAMETERS	AGREEMENT	COHEN'S KAPPA
Bilateral chewing	92%	0.80597
Cyclic chewing	96%	0.74999
Cutting ability	100%	0.0
Bolus formarion	76%	0.52112

Table 5

Parameters	Bilateral	Cyclic	Cutting	Bolus
Video 1	Yes/No	Yes	Yes/No	Yes/No
Video 2	Yes	Yes	Yes	Yes
Video 3	Yes	Yes	Yes	No
Video 4	Yes	Yes	Yes/No	Yes/No
Video 5	Yes/No	Yes	Yes/No	No
Video 6	Yes	Yes	Yes	Yes/No
Video 7	Yes	Yes	Yes	Yes
Video 8	Yes	Yes	Yes	Yes/No
Video 9	Yes	Yes	No	Yes/No
Video10	Yes/No	Yes	Yes/No	No

Table 6

Parameters	Bilateral	Cyclic	Cutting	Bolus
Video 1	Yes/No	Yes	Yes	No
Video 2	Yes	Yes	Yes	Yes
Video 3	Yes	Yes	Yes	Yes
Video 4	Yes	Yes	Yes/No	No
Video 5	Yes/No	Yes	No	No
Video 6	Yes	Yes	Yes	Yes
Video 7	Yes	Yes	Yes	No
Video 8	Yes	Yes	Yes	Yes/No
Video 9	Yes	Yes	Yes	Yes
Video10	Yes	Yes	Yes	No

Table 7

PARAMETERS	AGREEMENT	COHEN'S KAPPA
Bilateral chewing	100%	0.0
Cyclic chewing	100%	0.0
Cutting ability	46%	0.04597
Bolus formariion	38%	0.24657

DISCUSSION

Mastication can be assessed by either objective (i.e. using instruments) or by subjective (questionnaire or artificial and natural food) methods. Throughout the years, clinical studies concerning chewing performance searched for a quantifiable, objective parameter that could be performed in a clinical setting and is reliable enough to present the status of mastication.^[9]

Mastication is often assessed in old age and neurological impairments but it is rarely assisted in normal children. The mechanical breakage of foods makes enzymatic processing easier in the digestive system, since this mechanism is influenced by the way that foods are chewed. It provides stimulus and proper function to the normal development of the maxilla and mandible.^[11]

Supporting the development of efficient and thorough mastication during early childhood could lead to many benefits in adulthood. There is a clear nutritional benefit in the development of efficient mastication. In addition, the decrease in particle size in the bolus leads to nutritional advantages, which have been demonstrated in vitro and in vivo with smaller particle size allowing faster macro nutrient hydrolysis and better molecular diffusion from the food to the lumen, both resulting in better nutrient uptake.^[10]

Food hardness is sensed during mastication and affects jaw muscle activity, masticatory force and mandibular jaw movements. Food characteristics have a large influence on the number of chewing cycles needed to prepare the food for swallowing.^[12] Hard foods require more chewing cycles as more time is needed to break the food down and to add enough saliva to form a cohesive bolus suitable for swallowing. Carrot, peanuts and similar hard food items have been used as interventions in many studies.^[8]

In the present study, carrot was used as test material because its easy to standardized and can be cut into pieces.

Methods, such as optical scanning and mixing of differently colored chewing gums, have been employed for the determination of masticatory performance, but natural food proven to be more reliable and sensitive as well as easier to use.^[9]

This being a preliminary study a sample size of ten was considered adequate.^[14] Children 6 to 12 years of age were recruited for the following reasons. Generally, by this age with the eruption of all primary incisors children have certain ability of mastication. Also, with the eruption of first

permanent teeth, again the mastication ability develops further. Therefore, we wanted to standardized the age group of mixed dentition. ^[13]

This is a part study of ongoing dissertation work. The study was conducted by two residents and one professor of the department. The professor has experience in oro-facial functional assessment. He has published articles on functional assessment.

LIMITATIONS

1. This being a pilot study was based on a convenient sample, and therefore, there was representation from the small population.
2. Hawthorne effect (i.e., observer bias): The children might have chew differently when they were aware that they are being observed. We recorded only one mastication cycle, probably a few more mastication cycle could have been recorded without the observer being present and one of the cycles could have been chosen for the study.
3. For more precise assessment of cutting ability the sizes of cut pieces could either be measured in expectorant or pass through sieving.
4. To assess the bolus formation the area of coverage of the chewed mass on tongue could be considered a standard assessment

CONCLUSION

Based on our assessment the proposed scale of mastication appears reliable with respect to bilateral and cyclic chewing [high kappa value suggestive of strong agreement] whereas with respect to cutting ability and bolus formation it shows moderate reliability.

RECOMMENDATIONS

We recommend more research with proper working definitions of different stages of mastication and inclusion of the criteria that has been specified in the discussion for the purpose of validation.

DISCLAIMER

Authors declare no conflict of interest.

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REFERENCES

1. Stevenson RD & Allaire JH (1991) The development of normal feeding and swallowing. *Pediatric in North Am* 38,1439–1453.
2. Serel Arslan S, Demir N, Barak Dolgun A, Karaduman AA. Development of a new instrument for determining the level of chewing function in children
3. n. *J Oral Rehabil.* 2016 Jul;43(7):488- 95.

4. Dan & Kohyama, 2007; Peyron, Lassauzay, & Woda, 2002; Simione et al., 2018; Woda, Foster, Mishellany, & Peyron, 2006). (Lee, Yang, Ho, & Lee, 2014; Schwartz, Vandenberghe, Descamps, Sulmont-Rossé, Tournier, & Feron, 2018).
5. Fukushima-Nakayama Y, Ono T, Hayashi M, Inoue M, Wake H, Ono T, Nakashima T. Reduced Mastication Impairs Memory Function. *J Dent Res.* 2017 Aug;96(9):1058-1066. doi: 10.1177/0022034517708771. Epub 2017 Jun 16. PMID: 28621563.
6. Gavião MB, Raymundo VG, Sobrinho LC. Masticatory efficiency in children with primary dentition. *Pediatr Dent.* 2001 Nov-Dec;23(6):499-505
7. Le Reverend, Edelson, & Loret, 2014; Nicklaus, Demonteil, & Tournier, 2015
8. Carole Tournier, Lauriane Demonteil, Francis Canon, Agnès Marduel, Gilles Feron, et al.. A new masticatory performance assessment method for infants: a feasibility study. *Journal of Texture Studies, Wiley-Blackwell*, 2019, 50 (3), pp.237-247.
9. Gonçalves TMSV, Schimmel M, van der Bilt A, Chen J, van der Glas HW, Kohyama K, Hennequin M, Peyron MA, Woda A, Leles CR, José Pereira L. Consensus on the terminologies and methodologies for masticatory assessment. *J Oral Rehabil.* 2021 Jun;48(6):745-761.
10. Guyton-and-Hall-Textbook-of-Medical-Physiology12th-Ed
11. Remijn L, Speyer R, Groen BE, Holtus PC, van Limbeek J, Nijhuis-van der Sanden MW. Assessment of mastication in healthy children and children with cerebral palsy: a validity and consistency study. *J Oral Rehabil.* 2013 May;40(5):336-47. doi: 10.1111/joor.12040. Epub 2013 Feb 28. PMID: 23445464.
12. Toro A, Buschang PH, Throckmorton G, Roldán S. Masticatory performance in children and adolescents with Class I and II malocclusions. *Eur J Orthod.* 2006 Apr;28(2):112-9. doi: 10.1093/ejo/cji080. Epub 2005 Nov 4. PMID: 16272209.
13. Gavião MB, Raymundo VG, Rentes AM. Masticatory performance and bite force in children with primary dentition. *Braz Oral Res.* 2007 Apr-Jun;21(2):146-52. doi: 10.1590/s1806-83242007000200009. PMID: 17589650.
14. Whitehead AL, Julious SA, Cooper CL, Campbell MJ. Estimating the sample size for a pilot randomised trial to minimise the overall trial sample size for the external pilot and main trial for a continuous outcome variable. *Stat Methods Med Res.* 2016 Jun;25(3):1057-73. doi: 10.1177/0962280215588241. Epub 2015 Jun 19. PMID: 26092476; PMCID: PMC4876429.

