An Ultrasonographic assessment of Swallowing patterns in Mature and Retained Infantile Swallow: A Systematic Review

[1]Dr. Anjali Nandanwar, [2]Dr. Rashmi Jawalekar, [3]Dr. Aakash Simson, [4]Dr. Shivani Choudhary, [5]Dr. Sonam Batra, [6]Dr. Prajakta Joshi

[1,4,5,6]Post Graduate student, [2]Professor and Head, Department of Orthodontics and Dentofacial Orthopedics, Swargiya Dadasaheb Kalmegh Smruti Dental College and Hospital, Nagpur, Maharashtra, India
[3]Junior Resident, Department of Radiodiagnosis, All India Institute of Medical Sciences, Bibinagar, Telangana, India

Corresponding author:Dr. Anjali Nandanwar
dranjalinandanwar@gmail.com

ABSTRACT

Background: The assessment of swallowing pattern is crucial for the diagnosis and management of swallowing disorders.Clinicians can better understand the underlying causes of tongue thrusting/ abnormal swallowing patterns,by using ultrasound to visualize the movement of the tongue, pharynx, and larynx during swallowing and develop appropriate treatment plans. In this study, we aim to use ultrasonography, a non-invasive and cost-effective approach to evaluate the swallowing patterns of mature swallowers and those with retained infantile swallow patterns. The dynamics of swallowing in real-time can be assessed in toto by the use of Ultrasonography.

Aim: This systematic review is aimed to elucidate the question: Is there any difference between the swallowing patterns in patients with Mature swallow and with Retained Infantile swallow.

Objective: To systematically review the literature in order to produce a database of outcome variables to distinguish between mature swallow and retained infantile swallow.

Design, data sources, and methods: The electronic databases such as MEDLINE (NCBI PubMed and PMC),Scopus, Cochrane Central Register of Controlled Trials (CCRCT), Web of science, Science Direct, Google Scholar, EMBASE, EBSCOwere systematically searched to obtain the articles related to ultrasonography and swallowing from the year 1983. The reviewers assessed the risk of bias of individual studies with the Cochrane risk of bias tool, excluding RCTs with a high risk of bias in any domain.

Results: A sum of 712 relevant titles was redeemed from various medical, dental and orthodontic journals. A total of 5 articles assessing the different swallowing patterns by ultrasonography were shortlisted according to the inclusion and the exclusion criteria and were included in this systematic review after thorough scrutiny, meticulous screenings of abstracts and on duplicate removal. 80% of these studies had low risk of bias.

Conclusions: Ultrasonography is an effective way to objectively assess tongue posture and could become an important part of functional diagnostic tool before, during, and after orthodontic treatment.

Keywords: Ultrasonography, Mature swallow, Retained Infantile swallow

INTRODUCTION

Assessing the ability to swallow accurately requires not only a comprehensive understanding of the anatomical and physiological processes related to swallowing, but also familiarity with the instruments used for evaluating swallowing. Swallowing, also known as deglutition, involves preparing food into a cohesive bolus and then moving it through the oral, pharyngeal, laryngeal, and oesophageal mechanisms; involved in the act of swallowing, finally taking the bolus into the stomach. Successful swallowing depends on the structural and physiological integrity of these mechanisms. Even though swallowing appears effortless for most people, it involves various aspects of the central nervous system, multiple bones in the head and neck, and approximately 40 pairs of muscles thatstretch from the mouth to the esophagus.[1] Cranial nerves such as trigeminal (V), facial (VII), glossopharyngeal (IX), vagus (X), and hypoglossal (XII) are also involved in the act of swallowing.

The tongue is a vital muscle for breathing, chewing, swallowing, and speaking. It is divided into five parts anatomically and is innervated by multiple cranial nerves (trigeminal, facial, glossopharyngeal, vagus, accessory, and hypoglossal). The tongue helps in oral preparation, oral transit, and the initiation of the pharyngeal phase of swallowing. Additionally, the base of the tongue assists in elevating the larynx and protecting the airway during swallowing. The tongue usually rests on the lingual part of the maxillary anterior dentoalveolar area during swallowing.There is minimal perioral muscular contraction or constant forward posture of the tongue. Closure of the lips helps prepare and propel the food downwards during swallowing. The cheeks, made up of muscles and fat, are located on the sides of the oral cavity which help in directing the food during chewing.

In mature swallowing pattern, the oral sealobtained by closure of lips and position of tongue increases the intraoral pressure helping in propulsion of bolus into the Oesophagus.Infants have more fat in their cheeks reducing the size of the oral cavity and generating negative pressure during sucking.Infants typically thrust their tongues forward while swallowing,whereasin a mature swallowing ,the tongue touches rugae of palate. The development of infantile swallowing into a mature swallowing pattern is a gradual process that typically occurs between the ages of two to four years.[2] During infancy, infants have a reflexive swallowing pattern that is primarily characterized by a sucking and swallowing motion. As they grow and their oral motor skills develop, their swallowing pattern undergoes significant changes.

Around the age of six months, infants begin introducing solid foods into their diet, which helps in the development of more mature swallowing skills. As they progress through the first year, their swallowing becomes more coordinated, and they learn to manipulate food and liquids in their mouths more effectively.

Between the ages of one to two years, toddlers transition from using a sucking pattern to a more mature swallowing pattern. They start to develop a rotary chewing motion, which allows them to break down solid foods into smaller pieces. During this stage, they also learn to move food from the front to the back of the mouth using their tongue.

By the age of two to four years, most children have developed a fully mature swallowing pattern. They can effectively chew and swallow a variety of textures and consistencies without difficulty. They have better control over their tongue and jaw movements, allowing them to manipulate food and liquids more efficiently during the swallowing process.

The fusion of structures involved in swallowing takes place between the 9th and 12th week of development, and the hard and soft palates fuse at approximately the 12th week. The pharyngeal swallow begins between the 13th and 16th week, and suckling begins as the pharyngeal swallow strengthens in the 17th week.

According to a study by Comrie and Helm (1997), foetuses are capable of sucking and swallowing amniotic fluid as early as 13 weeks of gestation, and the volume of swallowing increases with gestational age.[3] Another study conducted on 69 subjects by Miller et al (62 normal controls and seven at-risk test cases) found that 84.6% of foetuses demonstrated swallowing activity as early as 15 weeks and 1 day gestational age.[4] This study also revealed that the most active period of swallowing occurs between 17 and 30 weeks gestation. During weeks four to eight, six branchial arches develop into the essential muscles, cranial nerves, and skeleton of the head and neck required for successful swallowing. Any birth defects involving these arches can potentially impact swallowing ability.

Foetal swallowing activity is markedly different from that of the adult,[5] with spontaneous foetal swallowing occurring at a higher rate compared to spontaneous adult drinking activity. This high rate of foetal swallowing is critical for the regulation of amniotic fluid volume and the development of the foetal gastrointestinal tract, allowing for sufficient weight gain in the foetus to proceed through the gestational period.[6]

Retained infantile swallow , or tongue thrusting, is a condition in which an individual continues to use the swallowing pattern that is typically used by infants, even into adulthood. This swallowing pattern involves the tongue thrusting forward and making contact with the front teeth during swallowing,[7] which is normal for infants but is replaced by a mature swallow pattern as the child grows. Retained infantile swallow can lead to speech difficulties, dental malocclusion, and other problems. It is important to diagnose and treat this condition, as it can affect an individual's quality of life. During infantile swallow, the tongue is positioned too far forward in the mouth and may push against the front teeth, leading to a forward open bite or malocclusion. The constant pressure from the tongue can also cause the teeth to shift or become misaligned over time, leading to crooked teeth. Furthermore, infantile swallow can also lead to mouth breathing, which can further exacerbate dental malocclusion. Mouth breathing can result in a dry mouth, which reduces saliva production and can lead to tooth decay and gum disease. It can also cause the lips and facial muscles to become weak, leading to facial abnormalities and speech problems.

Therefore, it is important to identify and treat infantile swallow early to prevent these negative effects on the dentoalveolar complex. An orthodontist can provide specialized treatment to correct the tongue position and help the child develop proper swallowing patterns.

Symptoms of tongue thrusting include the tongue resting in a forward position, perioral muscle contraction (excessive activity of the mentalis and orbicularis oris muscles), excessive buccinator hyperactivity, and swallowing without the necessary tooth contact. Tongue thrusting has been found to be more prevalent in children between the ages of 4 to 6 (40-80%) and less prevalent in those between 12 and 15 (3-25%), with varying rates due to different definitions of the condition. Prolonged tongue thrusting has been associated with an open bite, although it's not clear whether the open bite is a cause or an effect of the habit. Tongue thrusting with an open bite has been linked to long facial patterns and proclination of upper anterior teeth. Other associated features include a high and/or narrow maxillary arch and Class II div I malocclusion. While tongue thrusting may lead to lisping or impaired speech, some patients do not experience changes in their sibilant production.

In the past, methods such as radio cinematography, electromyography, and electromagnetic articulography have been used to evaluate tongue movements. However, these techniques are no longer considered suitable for clinical use due to their disadvantages, including prolonged chair time and the presence of receiver coils and wires that can affect swallowing.Ethical considerations a regarding x-ray exposure also needs consideration.. Advances in ultrasonography, particularly 3D ultrasonography, are now providing new opportunities for real-time and dynamic functional examination of oral structures, which could greatly assist in functional diagnostics.

Ultrasound technology can provide valuable information about a patient's swallowing patterns and safety by measuring the movement of the hyoid bone. Since the hyoid bone is connected to various muscles involved in swallowing, it is an essential indicator of the integrity of the hyoid/larynx/epiglottis unit, which plays a crucial role in airway protection during swallowing. With ultrasound, it is possible to accurately assess a patient's swallowing reflex by measuring the temporal distance and movement of the hyoid bone. This technique allows for real-time visualization and frame-by-frame analysis of swallowing patterns, which can aid in the diagnosis and treatment of swallowing disorders. The availability of ultrasonic equipment has improved significantly, making this non-invasive technique accessible for researchers and therapists in speech-language pathology. Ultrasound imaging can also be used to study tongue shapes and motor control of speech, expanding the scope of phonetic research.

OBJECTIVE

The objective of this systematic review is to collect, compile and review the accessible evidence on use of Ultrasonography to find difference in swallowing patterns in mature swallow and retained infantile swallow.

FOCUSED QUESTION

What is the difference between the swallowing patterns in mature swallow and retained infantile swallow?

MATERIAL AND METHODS

PROTOCOL

This systematic review is written and conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA Statement) checklist recommendations and was registered on PROSPERO (International prospective register of systematic reviews). (protocol number # CRD42023402724).

ELIGIBILITY CRITERIA

Articles related to ultrasonography and swallowing were collected from different databases. Thefollowingdatabaseswerethoroughlysearched:MEDLINE(NCBIPubMedandPMC),Scopus, CochraneCentralRegisterofControlledTrials(CCRCT),Web of science, ScienceDirect, GoogleScholar, EMBASE, EBSCO .

The review authors examined these journals following the guidance of the Cochrane Oral Health Group's Journal Hand searchers' Manual.

The reference lists of all the included studies were assessed to obtain additional eligible papers. The search strategy included the terms relating to or describing the study domain and intervention. The terms were combined with the Cochrane MEDLINE filter for controlled trials of interventions.

INCLUSION CRITERIA

- Swallowing patterns and ultrasonography related articles were considered.
- Randomized controlled trial study articles were collected which were published from year 1983 to 2022.
- All articles that were in English language were included.

EXCLUSION CRITERIA

- Case reports, case series, uncontrolled studies, review articles, opinion articles, studies on animal teeth were considered "Non-eligible" for present systematic review.
- Articles, in which diagnostic technique was other than ultrasonography was used to assess swallowing.
- All articles published before 1983 and after year 2022.
- Articles that were not in English language were excluded.

SEARCH STRATEGY

- The studies to be included in present systematic review were searched by two independent reviewers and in case of discrepancy, a third examiner intervened to resolve the difference in opinion. The following combinations of title, abstract, Medical Subject Heading Terms (MeSH) and keywords were used to search through the above-mentioned databases – (Ultrasound, Ultrasonography OR Ultrasonographical) AND (Swallowing OR Swallow OR Mature Swallow OR Tongue thrust OR Retained Infantile Swallow).(Table 1,2and 3)

Table 1- Primary and Secondary keyword

Primary Keywords	Secondary Keywords
Ultrasonography	Ultrasound
Swallowing pattern	Ultrasonographical
Mature swallow	Tongue thrusting
Retained Infantile swallow	

Table 2: Distribution of the journals in which the articles are published

Sr no	Name of journal	Number of articles
01	Journal of Orofacial Orthopaedics	01
02	American journal of orthodontics and dentofacial orthopaedics	02
03	European Journal of Orthodontics	02

Table 3-Electronic Search approach for Each Database

Keywords	No of articles searched	No of articles selected	Reason for exclusion
Ultrasonography and swallowing patterns	575	2	Case reports, Pathologic diagnosis
Ultrasonography and mature swallow	1	1	-
Ultrasonography and Retained Infantile swallow	0	0	-
Ultrasonography and Tongue thrusting	23	2	Case reports, Unclear about swallowing patterns

STUDY SELECTION AND IDENTIFICATION

The articles evaluating the swallowing patterns by ultrasonography were first selected from the database by reading titles and abstracts. The duplicate records were identified and removed.The titles and abstracts of the results of the search for desirable articles based on the PICO strategy were assessed by two review authors independently (Figure 1).

PRISMA FLOW DIAGRAM OF SYSTEMATIC REVIEW

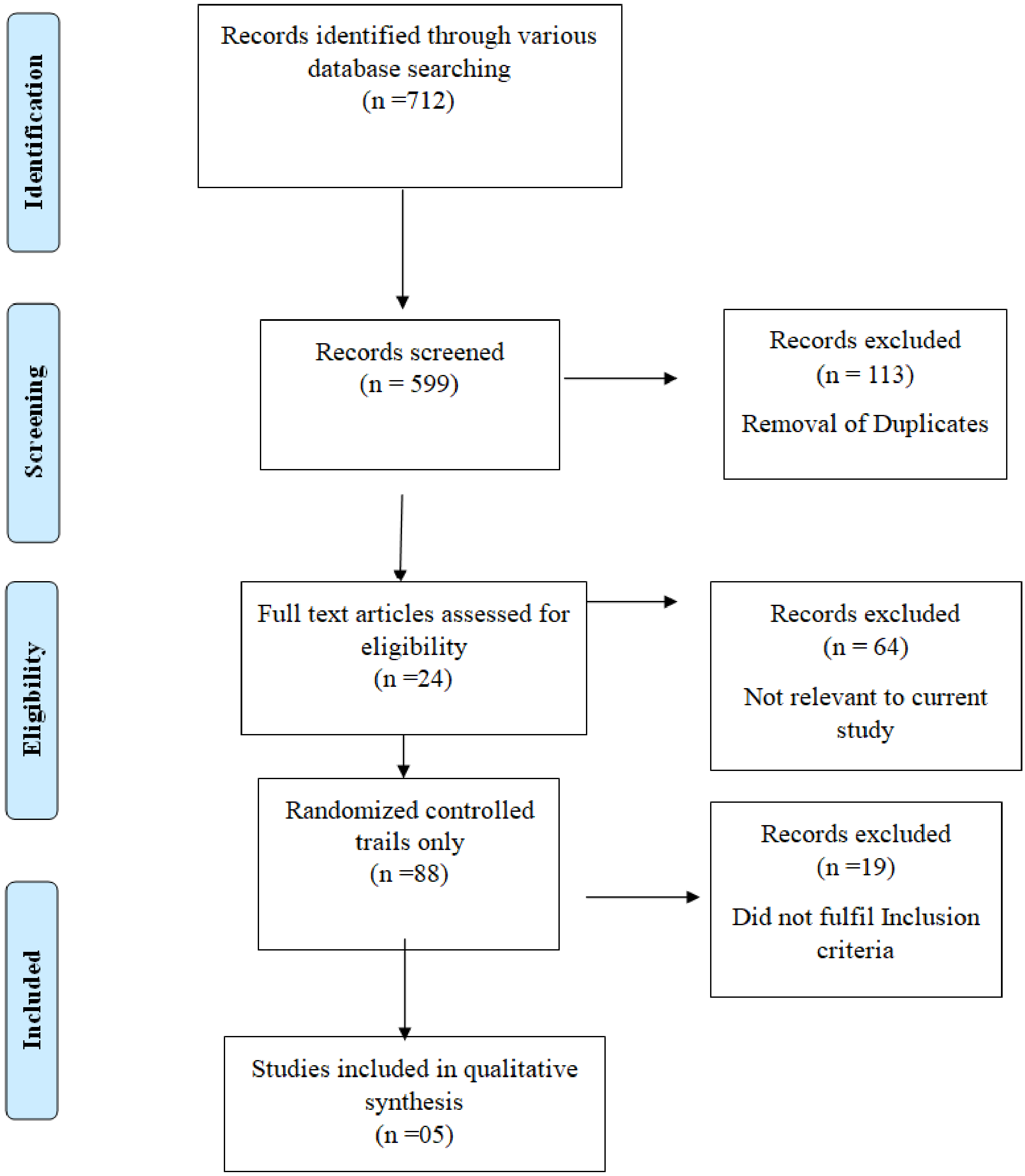


Figure 1-PRISMA flow diagram of the included and excluded records

DATA COLLECTION PROCESS

After a thorough electronic and manual search using the above-mentioned search strategy, studies obtained through duplicate searches were eliminated and the title and abstract of plausible eligible studies were noted. Furthermore, studies which did not fulfill the eligibility criteria were eliminated. In the next phase, full text detailed reading of the narrowed down studies was carried out, and studies that do not fulfill the systematic review criteria were excluded. The formal screening and data extraction were performed independently by two individual review team members. Any disagreement between them over the eligibility of particular studies were resolved through discussion with a third reviewer.

RISK OF BIAS ASSESSMENT IN INDIVIDIAL STUDIES

All the eligible studies were subjected to a qualitative assessment, performed for every eligible study independently using risk of bias (quality) assessment. The Revised Cochrane Risk-of-Bias tool for Randomized trials, Version 2.0 (RoB 2) was used to perform the quality assessment of eligible studies.

An overall risk of bias was determined for each study considering individual risk of bias judgement for each domain and an overall risk of bias judgement and direction of the bias was concomitantly determined. Disagreements between the review authors over the risk of bias in particular studies were resolved by discussion, with the involvement of a third review author, wherever necessary.

SYNTHESIS OF RESULTS

STUDY SELECTION

A comprehensive search from multiple databases resulted in 712 articles. Articles of relevance pertaining to the current review were identified by two independent reviewers and 113 duplicates were removed. Then filter of randomized controlled trail was applied which gave result of 88 articles. After screening 64 records were removed because of their irrelevance. 24 articles were selected for full text evaluation after screening the tittle and abstracts. Eligibility of individual studies was determined by clearly set inclusion and exclusion criteria. 19 articles were excluded after through reading of material methodology section of each article, since they did not fulfil the inclusion criteria. 5 articles fulfilled the criteria for present systematic review.

The extracted data was analysed for the measured variables were recorded and compared. (Table 4 and 5)

Table 4- List of Included studies

Author and year of study	Study design	Method used	Subjects	Control (n)	Experimental (n)	Results
Peng et al (2003)[8]	ECS	B+M-mode ultrasonography technique	26	14	12	Observation of the dorsum of the tongue or tongue tip with ultrasonography is of limited value for the differentiation of visceral and somatic swallowing .In the initial phase of swallowing, the genioglossus muscle is a means of differentiating between a visceral and a somatic swallowing pattern.
Peng et al (2004)[9]	ECS	A cushion scanning technique in combination with M-mode ultrasound	55	40	15	The centre of the tongue might serve as an ideal representative of the whole tongue and can give the observer a brief view of whole-tongue movement during swallowing. The tongue movement of a tongue-thrust swallower is slower in the late transport

						phase (IIb) and quicker in the early final phase (IIIa) than in mature swallowers.
Volk et al (2010)[10]	ECS	3- dimensional (3D) ultrasonography	50	23	27	The results showed that 81.5% of children with unilateral posterior crossbite demonstrated posture on the mouth floor, characterized by a central groove and expressed concavity on the tongue dorsum, compared to only 34.8% of those with normal deciduous dentition suggesting that 3D ultrasonography is an effective way to objectively assess tongue posture.
Ovsenik et al (2014)[11]	ECS	B-mode and M-mode ultrasonography	45	22	23	The duration of phase IIb and the entire swallowing act was significantly prolonged, and the range of tongue movement was significantly larger in the (Unilateral crossbite)ULCB group. Furthermore, the speed of tongue movement was significantly higher in the ULCB group during phase IIa. These findings suggest that changes in tongue function during swallowing may also contribute to the development of ULCB.
Galen et al (2010)[12]	ECS	B-mode and M-mode ultrasonography	24	13	11	They found that the amplitude and velocity of vertical tongue movement, as well as total swallowing duration, revealed wide intra- and interindividual variability and were not suitable for differentiating between visceral and somatic swallowing suggesting that the ultrasound methods used in the study may not be suitable for differentiating between visceral and somatic swallowing patterns.

ECS: Experimental controlled study

Table 5- List of excluded studies

Reference number	Author and year of study	Study title	Reason for exclusion
13	Fujiki et al (2004)	Relationship between maxillofacial morphology and deglutitive tongue movement in patients with anterior open bite	Cineradiography was used as the tool for assessment of swallowing pattern
14	Eslamian et al (2006)	Tongue to palate contact during speech in subjects with and without a tongue thrust.	Did not fulfil the inclusion criteriaElectropalatovision device was used as the assessment tool
15	Zeidler (2007)	Ultrasonic normative swallowing data in three/four year old children.	Doctoral dissertation
16	Miller et al (2007)	Preliminary Ultrasound Observation of Lingual Movement Patterns During Nutritive versus Non-nutritive Sucking in a Premature Infant	Case report
17	Xue et al (2009)	Ultrasonographic evaluation of tongue movement during swallowing in severe skeletal Class III malocclusion in adult patients	Article in Chinese language
18	Dixit et al (2013)	Comparison of soft-tissue, dental, and skeletal characteristics in children with and without tongue thrusting habit	Tongue thrusting not assessed by ultrasonography
19	Sambor (2015)	Incorrect patterns of swallowing and tongue resting position and the articulatory structure of phonemes realisations in adults	Doctoral dissertation

20	Matsuo et al (2020)	Evaluation of swallowing movement using ultrasonography	Unclear about the outcome

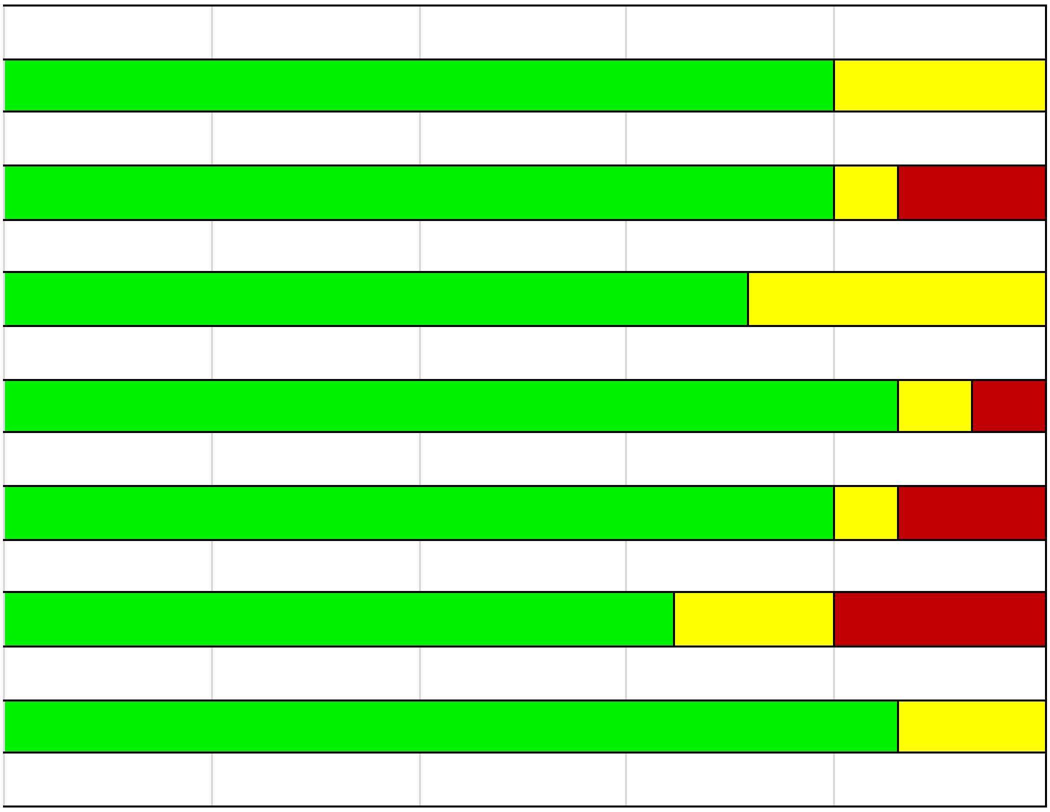
RISK OF BIAS

Cochrane risk of Bias assessment was done. Risk of bias was evaluated for each question. For each question-based entry the judgment was: “Yes, for low risk of bias” and a point were allocated (*), and “No, for high risk of bias” and a point was not allocated. The questions evaluated in each study were based on the following criteria from the Newcastle Ottawa scale: representativeness of the sample (evaluated by the methods of generation of samples, allocation concealment and sample calculation); sample size, non-respondents, ascertainment of the exposure, the subjects in different outcome groups are comparable, assessment of the outcome, statistical test. The representativeness criteria were evaluated through the sampling methods. The presence of a random component in the sequence generation was judged as low risk of bias. Allocation concealment was also used as a criterion for assessing representativeness. Thus, any method that precluded participants and researchers from foreseeing assignment was judged as low risk of bias.

The evaluation was done on answering the questions, answers were yes towards the low risk bias. Evaluations were done and after estimation were found to be low risk articles.(Table 6 and 7)

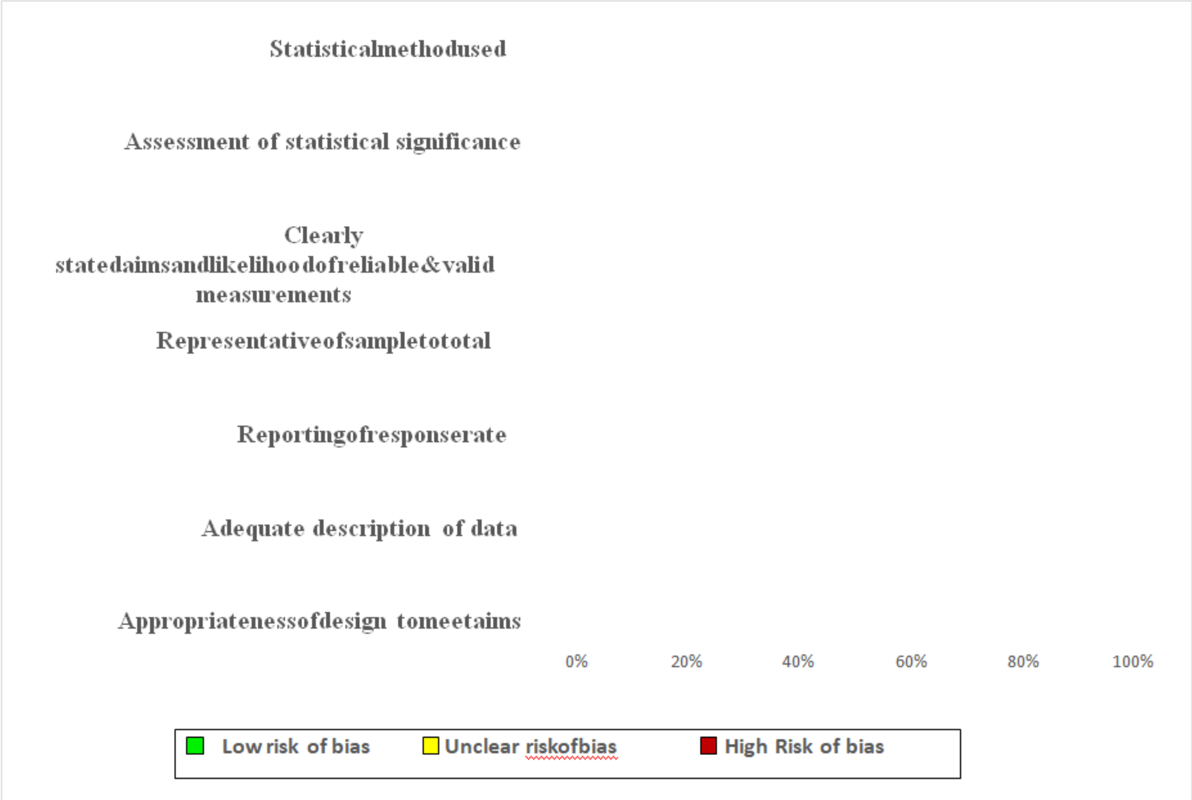
Table 6-Individual risk of Bias

- Studies(year)	Appropriateness of design to meetaims	Adequate description of data	Reporting of response rate	Representative of sample to total	Clearly stated aims and likelihood of reliable &valid measurements	Assessment of statistical significance	Statistical method used
Chein LunPengetal 2003	+	+	+	+	+	+	+
Chien LunPengetal 2003	?	+	+	?	+	+	+
JureVolketal 2008	+	+	+	+	+	+	+
MajaOvseniketal2014	+	+	+	+	?	+	+
SteffiGalen et al2010							



+/greencolor:lowrisk of bias;?/yellowcolor:someconcerns;−/redcolor:highriskofbias (AssessmentdoneusingCrombie'sitemusingAHRQMethodologyChecklistforCrossSectionalStudy)

Table 7- Overall risk of bias



DISCUSSION

Numerous researchers have examined the correlation between the form and function of the stomatognathic system. Some have proposed that the size, function and position of the tongue could have an impact on the surrounding oral environment. However, there has been a long-standing debate regarding whether tongue function causes malocclusion or simply adapts to changes in occlusion. While certain researchers consider the size and dysfunction of the tongue as crucial etiological factors in malocclusion development, others argue that tongue thrust swallowing is a consequence, rather than the cause, of malocclusion. Their reasoning is that it is difficult to seal off the front of the mouth during swallowing when there is an overjet or open bite. Therefore, it becomes important to investigate tongue thrusting clinically as well as ultrasonographically to prevent or intercept it in time.

Recently, Ultrasonography has become an increasingly valuable tool in the assessment and treatment of swallowing patterns, particularly in patients with tongue thrusting. By using ultrasound to visualize the movement of the tongue, pharynx, and larynx during swallowing, clinicians can better understand the underlying causes of tongue thrusting and develop appropriate treatment plans. One of the key advantages of ultrasonography in the assessment of swallowing patterns is, its non-invasive nature. Unlike other diagnostic tools such as endoscopy or barium swallow studies, ultrasonography does not require the use of radiation or sedation, making it a safer and more comfortable option for patients. Additionally, ultrasonography allows for real-time imaging of the swallowing process, providing clinicians with immediate feedback on the coordination and timing of the muscles involved in swallowing. The use of ultrasonography in the assessment of swallowing patterns has also led to the development of new treatment techniques. For example, visual feedback provided by ultrasonography can help patients improve their swallowing patterns by providing a clear image of the movements they need to make. This can be particularly useful for patients with neurological conditions or muscle weakness, who may have difficulty coordinating the movements required for safe and efficient swallowing. As research in this area continues, it is likely that ultrasonography will become an even more widely used diagnostic and treatment tool for patients with abnormal swallowing patterns.

Prior ultrasound studies examining tongue functions were restricted due to potential distortions caused by submental area movements during function, leading to misinterpretations of tongue movements. To address this issue, a dynamic tongue imaging technique called the **Cushion-scanning technique** was utilized by **Peng et al**[21]. This technique allowed for more accurate imaging of tongue movements. With the help of this technique, swallowing was analysed and divided into five stages using cushion-scanning technique-aided M-mode ultrasonograms.

With the advances in research in Ultrasonography, now Ultrasonography can be used to diagnose various neurological disorders as well.**Shawker et al** [22]visualized the movement of the tongue during single swallowing in both normal individuals and a patient with dysphagia and chronic aspiration, using non-invasive real-time ultrasound. The results suggest that dysphagia associated with cranial nerve weakness can be identified by the absence of normal tongue activity and mid-tongue bolus formation.

In a study by **Ardakani et al** [23]on the swallowing patterns of the tongue using B-mode ultrasonography , it was found that eight patients with a swallowing abnormality had Angle Class I occlusions, two had Class II, and the remaining ten patients had Class III. The majority of abnormal or inconsistent swallowing patterns were found in cases of mandibular prognathism. These findings were similar to the results of **Fuhrmann et al**[24] who found that Angle's Class III had the highest rate of abnormal swallowing based on video-based dynamic B-mode ultrasound .

Also, in a study by **Xue et al**[17]on the tongue movement during swallowing in skeletal Class III adult patients , it was found that the skeletal Class III adult patients had distinctly different tongue movements during swallowing. When compared with mature swallow, the skeletal Class III adult patients had longer phase 2 , phase 3 , longer total duration , faster speed in phase 1 and smaller range in phase 5. This is in accordance with the results of **Cheng et al**[25]who concluded that the motion magnitude of the early final phase (phase IIIa) of swallowing is related to dentofacial morphology, with a positive correlation between intermaxillary vertical dimension and tongue movement magnitude. Additionally, the duration of swallowing was found to be positively correlated with arch length. The study also found that the intermaxillary vertical dimension was positively correlated with the motion magnitude of the tongue movements, and that arch length increased with prolonged duration of swallowing.

Various etiological factors have been suggested in the literature for tongue thrusting and developing malocclusion. **Peng et al** [8] in a study on Differential diagnosis between infantile and mature swallowing with ultrasonography found that the dorsal surface of the tongue was not suitable for differentiating between the two swallowing patterns whereas the genioglossus muscle can serve as a reliable means for differentiating between visceral and somatic swallowers.

Retained Infantile swallow have been shown to develop various malocclusions and disrupt the occlusal stability. Also, abnormal tongue position can be used to identify any developing malocclusion which can become severe in due course of time. **Volk et al** [10]found that 81.5% of children with unilateral posterior crossbite demonstrated posture on the mouth floor, characterized by a central groove and expressed concavity on the tongue dorsum, compared to only 34.8% of those with normal deciduous dentition. These findings can be used to predict a developing crossbite in the future.

The results of **Ovsenik et al** [11]were similar , indicating that the swallowing pattern may be an important factor in the development of Unilateral posterior crossbite(ULCB). They found that the duration of phase IIb and the entire swallowing act was significantly prolonged, and the range of tongue movement was significantly larger in the ULCB group. Furthermore, the speed of tongue movement was significantly higher in the ULCB group during phase IIa. These findings suggest that changes in tongue function during swallowing may also contribute to the development of ULCB.

Nayak et al [26]found that there were significant differences in the duration and range of tongue movement after the insertion of the habit-breaking appliances. The habit breaking appliances caused remarkable changes in tongue position for both anterior and lateral tongue thrust patterns, shifting the tongue tip and anterior tongue dorsum upward toward the anterior palate, resembling that of a mature swallow pattern showing the potential effectiveness of habit-breaking appliances in correcting tongue thrusting and improving swallow patterns.

CONCLUSION

In conclusion, it can be said that ultrasonography is an effective way to objectively assess tongue posture and could become an important functional diagnostic tool before, during, and after orthodontic treatment. It is a valuable tool for assessing swallowing pattern and tongue thrusting in patients which could lead to various malocclusions. Ultrasonography provides real-time images of the oral and pharyngeal phases of swallowing, allowing clinicians to identify abnormalities and make more accurate diagnoses. Additionally, ultrasonography can detect subtle changes in muscle activity during swallowing that may not be visible during traditional assessments. Recently, with the advances like 3D Ultrasonography and Cushion Scanning technique, the misinterpretations of tongue movements caused by submental area movement during function have been eliminated.

The centre of the tongue might serve as an ideal representative of the whole tongue and can give the observer a brief view of whole-tongue movement during swallowing. Tongue thrusters demonstrated a central groove and expressed concavity on the tongue dorsum. The tongue movement of a tongue-thrust swallower is slower in the late transport phase (IIb) and quicker in the early final phase (IIIa) than in mature swallowers. Also, the genioglossus muscle is a means of differentiating between a visceral and a somatic swallowing pattern.

Overall, ultrasonography has shown to be effective in identifying the underlying causes of tongue thrusting, which can affect treatment planning to improve patient outcomes. However, it is important to note that ultrasonography should not be used as the sole diagnostic tool, as other factors such as patient history, clinical exam, and instrumental assessments may also be necessary. Nonetheless, ultrasonography can be a valuable complement to other diagnostic methods and can improve the overall assessment and management of Retained Infantile swallow.

REFERENCES

1. Broniatowski M, Sonies BC, Rubin JS, Bradshaw CR, Spiegel JR, Bastian RW, Kelly JH. Current evaluation and treatment of patients with swallowing disorders. Otolaryngology–Head and Neck Surgery. 1999 Apr;120(4):464-73.
2. Dixit UB, Shetty RM. Comparison of soft-tissue, dental, and skeletal characteristics in children with and without tongue thrusting habit. Contemporary Clinical Dentistry. 2013 Jan;4(1):2.
3. Comrie JD, Helm JM. Common feeding problems in the intensive care nursery: maturation, organization, evaluation, and management strategies. InSeminars in Speech and Language 1997 (Vol. 18, No. 03, pp. 239-261). © 1997 by Thieme Medical Publishers, Inc.
4. Miller JL, Sonies BC, Macedonia C. Emergence of oropharyngeal, laryngeal and swallowing activity in the developing fetal upper aerodigestive tract: an ultrasound evaluation. Early human development. 2003 Feb 1;71(1):61-87.
5. Ross MG, Nijland MJ. Development of ingestivebehavior. American Journal of Physiology-Regulatory, Integrative and Comparative Physiology. 1998 Apr 1;274(4):R879-93.
6. El-Haddad MA, Desai M, Gayle D, Ross MG. In utero development of fetal thirst and appetite: potential for programming. Journal of the Society for Gynecologic Investigation. 2004 Apr;11(3):123-30.
7. Hanson ML, Barnard LW, Case JL. Tongue-thrust in preschool children. Am J Orthod 1969;56:60-9
8. Peng CL, Jost-Brinkmann PG, Yoshida N, Miethke RR, Lin CT. Differential diagnosis between infantile and mature swallowing with ultrasonography. The European Journal of Orthodontics. 2003 Oct 1;25(5):451-6.
9. Peng CL, Jost-Brinkmann PG, Yoshida N, Chou HH, Lin CT. Comparison of tongue functions between mature and tongue-thrust swallowing—an ultrasound investigation. American journal of orthodontics and dentofacial orthopedics. 2004 May 1;125(5):562-70.
10. Volk J, Kadivec M, Mušič MM, Ovsenik M. Three-dimensional ultrasound diagnostics of tongue posture in children with unilateral posterior crossbite. American journal of orthodontics and dentofacial orthopedics. 2010 Nov 1;138(5):608-12.
11. Ovsenik M, Volk J, Marolt MM. A 2D ultrasound evaluation of swallowing in children with unilateral posterior crossbite. European Journal of Orthodontics. 2014 Dec1;36(6):665-71.

12. Galén S, Jost-Brinkmann PG. B-mode and M-mode Ultrasonography of Tongue Movements during Swallowing. Journal of Orofacial Orthopedics/Fortschritte der Kieferorthopadie. 2010 Mar 1;71(2).
13. Fujiki T, Inoue M, Miyawaki S, Nagasaki T, Tanimoto K, Takano-Yamamoto T. Relationship between maxillofacial morphology and deglutitive tongue movement in patients with anterior open bite. American journal of orthodontics and dentofacial orthopedics. 2004 Feb 1;125(2):160-7.
14. Eslamian L, Leilazpour AP. Tongue to palate contact during speech in subjects with and without a tongue thrust. The European Journal of Orthodontics. 2006 Oct 1;28(5):475-9.
15. Zeidler SJ. Ultrasonic Normative Swallowing Data in Three/four Year Old Children (Doctoral dissertation, Miami University).
16. Miller JL, Kang SM. Preliminary ultrasound observation of lingual movement patterns during nutritive versus non-nutritive sucking in a premature infant. Dysphagia. 2007 Apr;22:150-60.
17. Xue M, Gao XH, Pang XN, Bai YX. Ultrasonographic evaluation of tongue movement during swallowing in severe skeletal Class III malocclusion in adult patients. ZhonghuakouQiangyixue za zhi= ZhonghuaKouqiangYixueZazhi= Chinese Journal of Stomatology. 2009 May 1;44(5):289-92.
18. Dixit UB, Shetty RM. Comparison of soft-tissue, dental, and skeletal characteristics in children with and without tongue thrusting habit. Contemporary Clinical Dentistry. 2013 Jan;4(1):2.
19. SamBor B. Incorrect patterns of swallowing and tongue resting position and thearticulatory structure of phonemes realisations in adults. Logopedia.;43:139-75.
20. Matsuo T, Matsuyama M, Nakatani K, Mori N. Evaluation of swallowing movementusing ultrasonography. Radiological Physics and Technology. 2020 Mar;13:62-8.
21. Peng CL, Jost-Brinkmann PG, Miethke RR, Lin CT. Ultrasonographic measurement of tongue movement during swallowing. Journal of ultrasound in medicine. 2000 Jan;19(1):15-20.
22. Shawker TH, Sonies B, Stone M, Baum BJ. Real-time ultrasound visualization of tongue movement during swallowing. Journal of Clinical Ultrasound. 1983 Nov;11(9):485-90.
23. Ardakani FE. Evaluation of swallowing patterns of the tongue using real-time B-mode sonography. J Contemp Dent Pract. 2006 Jul 1;7(3):67-74.
24. Fuhrmann RA, Diedrich PR. B-mode ultrasound scanning of the tongue during swallowing. Dentomaxillofacial Radiology. 1994 Nov;23(4):211-5.
25. Cheng CF, Peng CL, Chiou HY, Tsai CY. Dentofacial morphology and tongue function during swallowing. American journal of orthodontics and dentofacial orthopedics. 2002Nov 1;122(5):491-9.
26. Nayak M, Patil SD, Kakanur M, More SA, Kumar SR, Thakur R. Effects of habit-breaking appliances on tongue movements during deglutition in children with tongue thrust swallowing using ultrasonography–A pilot study. Contemporary Clinical Dentistry.2020 Oct;11(4):350.