

Influence of Adhesive Use on Swallowing in Removable Complete Denture Wearers

Running Title: Denture Adhesive Effects on Swallowing

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ABSTRACT

Background: The objective of conventional complete dentures is to reestablish the functions of the stomatognathic system in edentulous individuals. Adhesives are used for denture retention to help the masticatory function. The objective of this investigation was to evaluate the effect of denture adhesive on the swallowing of complete denture wears. **Methods:** Nine upper and lower complete denture wearers and 14 individuals with teeth were assessed with videofluoroscopy at 30 frames by second and analyzed frame by frame. The denture wears subjects were assessed without dentures, with dentures without adhesive, and with dentures and adhesive. Duplicate assessments were made with swallows of 10-mL thin-liquid bolus, 10-mL extremely thick bolus, 5-g cookies, and 2-g toasts. **Results:** Laryngeal vestibule closure, pharyngeal transit, upper esophageal sphincter opening, and oropharyngeal transit took longer in denture wearers than in controls. Laryngeal vestibule closure time and upper esophageal sphincter opening when swallowing thin liquid were shorter with dentures and adhesive than without adhesive. With extremely thick bolus, the pharyngeal transit time and upper esophageal sphincter opening were shorter with adhesive use. Residues in the oral cavity occurred more frequently in the denture wearers than in the controls, for all boluses. Removable complete denture wearers have longer pharyngeal transit of thin liquid and extremely thick boluses, which decreases with adhesive use. **Conclusion:** Adhesive

use cause a favorable effect on pharyngeal swallowing of thin and thick boluses in complete denture wearers.

Keywords: Deglutition, Denture, Denture Bases, Denture Retention

INTRODUCTION

Removable conventional complete dentures are mucous-supported whose purpose is to adequately reestablish function and aesthetics, helping improve the quality of life of edentulous older adults. However, alveolar bone resorption compromises denture retention, support, and stability, harming its wearer [1]. Implants are indicated to solve this problem, but their use is limited by psychological conditions, systemic health, or socioeconomic factors [2].

Wearing and removing dentures may affect oropharyngeal movements and bolus transport during feeding [3,4]. Denture adhesives have as function to increase the adhesive and cohesive properties between the inner denture surface and mucosa, being an alternative that improves complete denture retention and stability on the supporting area, improve masticatory function, decrease food accumulation between the denture and mucosa [5,6], and improve the wearer's quality of life [7]. Adhesives ensure more efficient mastication, enabling fully ground and crushed food bolus and avoiding swallowing difficulties [8] without irritating the mucosa [9].

Dysphagia is characterized as any difficulty or discomfort in the passage of the food bolus from the mouth to the stomach [10]. These difficulties may result from neurological or muscle changes or mechanical obstacles [11]. With normal function, food bolus transportation in the oral cavity is estimated to take 1 to 2 seconds; in the pharynx, less than 1 second; and in the esophagus, 8 to 10 seconds [12]. However, this process may be changed by removable complete dentures or edentulousness [13]. So, adhesive use in combination with removable complete dentures may help the swallowing process.

Videofluoroscopy is considered the best method to assess the oral and pharyngeal phases of swallowing, as it dynamically assesses the transit of the swallowed material through the mouth, oropharynx, hypopharynx, and upper esophageal sphincter (UES) [14].

The objective of this investigation was to evaluate the effect of denture adhesive on the swallowing of individuals with complete dentures. The hypothesis was that adhesive use benefits swallowing in denture wearers, nearing the swallowing dynamics of individuals with teeth.

MATERIAL AND METHOD

Ethical Approval

This study was approved by the Human Research Ethics Committee of the School of Dentistry of Ribeirão Preto, University of São Paulo, Ribeirão Preto, São Paulo, Brazil (CAAE: 95824818.0.0000.5419). The subjects were included in the research after signing an informed consent form (ICF). The anonymity of the individuals was preserved.

Volunteers

The study included two groups of participants. The denture wearers group comprised completely edentulous individuals who wore mandibular as well as a maxillary denture

followed up at the School of Dentistry of Ribeirão Preto, University of São Paulo (FORP-USP). The control group comprised individuals with teeth recruited by personal invitation. All participants were initially interviewed to register their age, educational attainment, occupation, medical and dental history, and time of denture wearing (for those who wore it). They were also submitted to clinical examination to assess the denture-supporting tissues and the characteristics of the dentures, according to the inclusion and exclusion criteria.

Inclusion and Exclusion Criteria

Individuals with a mandibular as well as maxillary denture were invited to make up the denture wearers group. The base and teeth of the dentures were made of acrylic resin; they had been wearing them for a minimum of 3 months and a maximum of 5 years, in satisfactory wearing conditions and adequate maxillomandibular relationship, evaluating by expert professional. Individuals with lesions on the mucosa, fractured denture, or worn teeth were excluded. The 14 volunteers in the control group had at least 24 well-preserved teeth.

Individuals with restrictions on food intake, dysphagia, xerostomia, acute or chronic diseases, neurological diseases, or impaired cognitive function were not included. The denture wearers group subjects were submitted to three forms of swallowing assessment with videofluoroscopy, as follows: no wearing complete dentures, wearing dentures without adhesive, and wearing dentures with adhesive. The adhesive used was Corega Ultra® applied for seven days. Corega Ultra is composed of sodium/calcium mixed partial poly salts (methylvinylether/maleic acid), carboxymethylcellulose, mineral oil, and petroleum jelly (GlaxoSmithKline – Argentina).

The patients were given the adhesive along with a kit containing a denture brush (Denture brush – *Condor S.A.*, Santa Catarina, Brazil) and neutral liquid soap (*JOB Química, Produtos para Limpeza Ltda.*, Monte Alto, São Paulo, Brazil) for hygiene care; they also received written and verbal instructions. The participants were instructed to apply the adhesive daily, according to the manufacturer's instructions, on the inner surface of the upper and lower complete dentures and wear them throughout the day, removing them for hygiene after meals and reapplying the adhesive before wearing the dentures again. The patients were instructed to sleep at night without dentures.

Videofluoroscopy

The videofluoroscopic examination was made with an Arcomax angiograph (Philips, model BV 300, Veenpluis, the Netherlands), recording images at 30 frames per second. The subjects remained seated, sustaining usual cervical posture, feet flat on the floor, in the Frankfurt plane. The equipment was positioned to pick up transverse images of the mouth, pharynx, and upper part of the esophagus.

During the assessments, the volunteers were instructed to chew and/or swallow the thin liquid, thick and solid boluses, as they would normally do. Duplicate assessments were made by randomly ingesting liquid, thick bolus, and solid foods. The volunteers helped themselves with 10 mL of liquid, thick foods, cookie and toast as solid food. The denture wearers subjects were assessed in two moments. In the first one, they were assessed wearing the denture without adhesive and then without the dentures – in which case, the toast was not included. The second assessment took place after 7 days of using the adhesive daily; the subjects were wearing the

dentures with adhesive in the examination. The same ingestions were randomly repeated, though this time they were not assessed without dentures. The control group volunteers were assessed on a single occasion.

The thin liquid consistency was obtained by mixing 12 mL of liquid barium sulfate (Bariogel® 100%, Cristália, Brazil) into 28 mL of water. They were measured with a syringe and offered to the subjects in plastic cups in 10-mL servings. The thick consistency was obtained by mixing 30 mL of liquid barium sulfate into 70 mL of water and adding 3.6 g of food thickener (ThickenUpClear®, Nestle Health Science, Osthofen, Germany), which was offered to the subjects on a plastic spoon in 10-mL servings. For solid foods, they were served two 2.5-g cookies covered with 3-mL thick consistency and two 2-g toasts covered with 3-mL thick consistency. Toast swallow was assessed only wearing dentures both with and without adhesive and in the controls. In accordance of International Dysphagia Diet Standardisation Initiative (IDDSI) [15,16], the liquid consistency was classified as thin liquid (level 0 in the IDDSI classification), the thick consistency was classified as extremely thick (level 4 in the IDDSI classification), the cookie was classified as level 7 (easy to chew), and the toast as level 7 (regular).

The following parameters were observed and quantified in the videofluoroscopic images of the oral and pharyngeal phases of swallowing:

- a) Oral preparation time (OPT) – from holding the food with lip closure until the tongue movement in the retro-incisal area.
- b) Oral transit time (OTT) – from the tongue movement in the retro-incisal area until the tail of the bolus passed the mandibular ramus.
- c) Swallow reaction time (SRT) – from the arrival of the head of the bolus by the mandibular angle until the beginning of the rapid movement of the hyoid.
- d) Laryngeal vestibule closure time (LVT) – the time interval between the laryngeal vestibule closure and opening.
- e) Pharyngeal transit time (PTT) – from the passage of the head of the bolus by the mandibular angle until UES closure.
- f) Upper esophageal sphincter opening time (UESO) – the time interval between UES opening and closure.
- g) Oropharyngeal transit time (OPTT) – from the movement of the tip of the tongue in the retro-incisal area until UES closure.

The presence of post-swallow residues in the oral cavity and vallecula was also assessed. They were considered as either present or absent, and the final result was the percentage of swallows in which residues were observed.

Statistical Analysis

A mixed-effect linear regression model (random and fixed effects) was used for the comparisons involving continuous quantitative variables, using the SAS software version 9.4. Mixed effect linear models are used to analyze data with grouped responses (more than one measure for each subject) and in which the assumption of independence between observations in each group is not adequate [17]. The assumption in these models is that residues have a normal distribution with mean 0 and constant variance σ^2 . When this assumption was not observed, the response variables were transformed. The comparisons were made post-test

with orthogonal contrasts. Linear regression with robust variance was used in the assessment of residues [18]. All analyses were controlled for age and sex. The differences were considered significant when $p \leq 0.05$.

RESULTS

The subjects assessed were nine totally edentulous individuals, four women and five men, aged 56 to 77 years, with a mean age of 69 years; they had been wearing dentures for 3 months (minimum) to 5 years (maximum), median: 1 year and 2 months; and 14 healthy individuals, eight women and six men, aged 41 to 74 years, with a mean of 62 years, who formed the control group.

In the swallowing assessment of the four boluses, the laryngeal vestibule closure time, pharyngeal transit time, UES opening time, and oropharyngeal transit time took longer in the denture wearers subjects without dentures and with dentures, both with and without adhesive, than in the controls (Tables 1 and 2).

The oral preparation time with cookies took longer when the patients were not wearing dentures (Table 2). The oral transit time when swallowing thin liquid and cookies took longer in subjects with dentures and adhesive than in controls (Tables 1 and 2).

The comparison of denture wearers participants with and without adhesive revealed that the laryngeal vestibule closure time and UES opening time when swallowing thin liquid and the pharyngeal transit time and UES opening time when swallowing thick bolus took longer when they were not using adhesives than when they were using them (Table 1). The swallow reaction time when swallowing cookies took longer when the denture wearers were using adhesive than when they were not using them (Table 2).

Residues in the oral cavity occurred more frequently in the denture wearers regardless of wearing dentures or using adhesive than in the controls, for all boluses (Table 3). In the vallecula, the trend was toward a less frequent occurrence of residues when edentulous individuals were not wearing dentures (Table 3). Airway penetration was observed in both the denture wearers and control groups only when swallowing thin liquid. No aspiration occurred on any occasion.

DISCUSSION

This paper hypothesized that adhesive use combined with removable dentures by completely edentulous patients would influence the swallowing process, in comparison with not using adhesives. The results show that the dentures associated with adhesives wear promoted pharyngeal vestibule closure and UES opening duration with the thin liquid bolus, and pharyngeal transit and UES opening duration with the thick bolus similar to those of the control group and better than registered in the group that wear dentures without adhesives. The SRT took longer with dentures and adhesive than without adhesive when swallowing cookies; this difference was not observed with the toast. The influence on SRT of adhesive use and non-use must be related to bolus transit through the mouth and pharynx.

The time the bolus took to pass through the pharynx, measured by the pharyngeal transit duration and UES opening duration, tended to be shorter with the individual using adhesive. In

the examination without dentures and with dentures without adhesive, the pharyngeal transit time was prolonged, as previously reported in dysphagic patients wearing dentures [13]. The slower transit in individuals wearing complete dentures mean that they are at greater risk of aspiration than who do not wear dentures. This association was observed in children [19] and adults [20]. No bolus aspiration into the airways was observed in any of the patients and controls, in any of the swallowing assessments. This indicates that, although denture wearers may be at greater risk of bolus aspiration into the airways, this condition is not severe enough to cause aspirations frequently. However, it is important to highlight that the situation of the data collected in controlled environment and use of the specific foods can be contributed with the results.

Even though complete denture wearers are usually older, and the aging process may change the swallowing dynamics in a few parameters [21], this does not significantly occur in the swallowing time. Therefore, the differences found in the comparison with the control group must be due to their being completely edentulous and wearing complete dentures, rather than a consequence of aging. The ages were similar between the groups evaluated.

The greater amount and frequency of residues in the oral cavity, vallecula, and pyriform sinus may also represent a greater risk of aspiration of swallowed material into the airways [22,23]. However, to the best of our knowledge, there is no description in the literature of this complication occurring frequently in denture wearers with normal cognitive and swallowing conditions. The results in this study showed that wearing dentures with adhesive did not diminish residue accumulation in relation to wearing dentures without adhesive. The patients had residues less frequently not wearing dentures than wearing them, which may be a consequence of the shorter distance between the maxilla and mandible when they swallow without wearing dentures [18].

The pharyngeal transit time of the bolus was prolonged in edentulous patients with and without dentures, which indicate alteration in the pharyngeal swallowing mechanism.

Adhesive use is indicated to improve denture retention and patients' comfort when masticating [24,25] and, consequently, the oral preparation to swallow the food. However, the results showed that adhesive use affects some of the swallowing timing, particularly concerning the time taken in bolus swallow and transit. Nevertheless, the small changes observed may represent an improvement in the swallowing dynamics.

Wearing or not the dentures, either with or without adhesives, did not significantly influence the swallowing process dynamics of the evaluated boluses. This may result from the specialized and complex neurological and muscle control [26,27] to ensure safe and effective swallowing. When the neurological and/or muscular process is impaired, the oral feeding ability is changed, with serious consequences to nutrition and the quality of life [10]. Thus, wearing dentures favors the intake of nutritious food, as they help to grind them in mastication. On the other hand, swallowing does not depend on wearing dentures, either with or without adhesive. Adhesive use may improve the masticatory function and comfort [24,25] with favorable but no intense influence on the swallowing process.

Although few patients were assessed in this study, differences were verified between the groups. Future studies should analyze how difficult or easy it is to swallow with and without dentures based on the patients' self-assessments.

In conclusion, bolus transit takes longer in denture wearers subjects either wearing dentures or not than in people with an adequate number of teeth. Adhesive use for better denture retention decreased the swallowing transit time in complete denture wearers, nearing the transit time of individuals with teeth. Therefore, adhesive use has a favorable effect on pharyngeal swallowing of thin and thick bolus of complete denture wearers subjects.

Disclosure Statement

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Authors' Contributions

MR Montaldi, CV Fortes, AB Ribeiro and Cl HL da Silva participated in the study planning, data collection, discussion of results, manuscript preparation and the decision to submit the manuscript for publication. RO Dantas participated in the study planning, discussion of the results, manuscript preparation and the decision to submit the manuscript for publication.

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Table 1. Videofluoroscopic evaluation of oral and pharyngeal phases of swallowing, in milliseconds, after swallows of 10-mL thin liquid and 10-mL thick boluses, in controls and removable denture wearers – without dentures (ND), with dentures without adhesive (DNA), and with dentures and adhesive (DWA). Mean (SD)

		Controls	ND	DNA	DWA
THIN LIQUID	OPT	461 (264)	611 (494)	490 (392)	381 (191)
	OTT	240 (74)	274 (92)	282 (83)	300 (85)*
	SRT	84 (41)	100 (52)	115 (72)	135 (90)
	LVT	480 (97)	592 (167)*	660 (144)**	579 (102)*
	PTT	426 (82)	564 (72)*	596 (99)*	588 (82)*
	UESO	321 (85)	443 (48)*	475 (95)**	422 (78)*
	OPTT	438 (112)	571 (98)*	618 (83)* ^μ	584 (101)*
THICK BOLUS	OPT	1556 (1379)	1676 (1282)	1375 (1224)	1514 (604)
	OTT	239 (114)	342 (124)*	312 (136)	306 (102)
	SRT	77 (74)	102 (129)	169 (150)	123 (119)
	LVT	444 (131)	523 (81)*	606 (197)*	526 (98)*
	PTT	403 (102)	538 (128)*	592 (165)**	509 (116)*
	UESO	304 (64)	393 (67)*	401 (64)* ⁺	369 (55)*
	OPTT	477 (122)	637 (105)*	624 (136)*	590 (121)*

* $p \leq 0.05$ vs. controls; + $p \leq 0.05$ vs.DWA; $\mu p \leq 0.05$ vs. ND

OPT – Oral preparation time; OTT – Oral transit time; SRT – Swallow reaction time; LVT – Laryngeal vestibule closure time; PTT – Pharyngeal transit time; UESO – Upper esophageal sphincter opening; OPTT – Oropharyngeal transit time; SD – Standard deviation.

Table 2. Videofluoroscopic evaluation of the oral and pharyngeal phases of swallowing, in milliseconds, after swallows of chewed cookie and toast, in controls and removable denture wearers – without dentures (ND), with dentures without adhesive (DNA), and with dentures and adhesive (DWA). Mean (SD)

		Controls	ND	DNA	DWA
COOKIE	OPT	9722 (3843) ^μ	15875 (3945)	12115 (3774) ^μ	12290 (2788) ^μ
	OTT	238 (85)	284 (126)	291 (79)	328 (75)*
	SRT	76 (45)	59 (32)	47 (28) ⁺	94 (59)
	LVT	373 (65)	478 (128)*	541 (138)*	519 (115)*
	PTT	384 (60)	445 (66)*	443 (70)*	475 (63)*
	UESO	270 (39)	364 (64)*	354 (80)*	357 (53)*
	OPTT	471 (84)	591 (119)*	596 (101)*	611 (74)*
TOAST	OPT	12289 (5295)	-	18512 (4450)*	18736 (6481)*
	OTT	263 (75)	-	278 (78)	310 (84)
	SRT	111 (72)	-	59 (43)*	97 (54)
	LVT	350 (85)	-	574 (167)*	522 (129)*
	PTT	390 (65)	-	486 (60)*	475 (80)*
	UESO	256 (56)	-	368 (71)*	357 (60)*
	OPTT	486 (86)	-	582 (93)*	599 (73)*

* $p \leq 0.05$ vs. controls; ⁺ $p \leq 0.05$ vs. DWA; ^μ $p \leq 0.05$ vs. ND

OPT – Oral preparation time; OTT – Oral transit time; SRT – Swallow reaction time; VLT – Laryngeal vestibule closure time; PTT – Pharyngeal transit time; UESO – Upper esophageal sphincter opening; OPTT – Oropharyngeal transit time; SD – Standard deviation

Table 3. Frequency, in percentage of swallows, of residues in the oral cavity and vallecula, after swallowing thin-liquid bolus, extremely thick bolus, cookie, and toast boluses, in controls and removable denture wearers – without dentures (ND), with dentures without adhesive (DNA), and with dentures and adhesive (DWA).

		Controls	ND	DNA	DWA
ORAL	THIN LIQUID	10.7	77.8*	83.3*	94.4*
	THICK BOLUS	39.3	83.3*	94.4*	83.3*
	COOKIE	21.4	82.3*	72.2*	88.9*
	TOAST	25.0	-	72.2*	83.3*
VALLECULA	THIN LIQUID	35.7	27.8	38.9	33.3 ⁺
	THICK BOLUS	46.4	22.2*	16.7*	33.3
	COOKIE	35.7	5.9*	16.7	38.9 ⁺
	TOAST	32.1	-	22.2	38.9

* $p \leq 0.05$ vs. controls; ⁺ $p \leq 0.05$ vs. ND