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ORIGINAL ARTICLE

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Early swallowing intervention after free flap reconstruction for oral cancer: A systematic review and meta-analysis

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Abstract

Objectives: This study aimed to summarize the state of current literature and evaluate evidence for timing, methods, and effects of early intervention in patients after free flap reconstruction.

Methods: A comprehensive search was conducted in nine databases. The methodological quality of literature was assessed according to the JBI Critical Appraisal Tools.

Results: Eight studies were finally included. Most studies started the intervention within 1 to 2 weeks after surgery with multiple swallowing training measures. The results of meta-analysis showed that swallowing intervention could improve swallowing function (SMD = −1.03, 95%CI [−1.37, −0.69], $Z = 5.95$, $p < 0.01$) and the quality of life (SMD = 1.52, 95%CI [0.97, 2.07], $Z = 5.43$, $p < 0.01$).

Conclusion: Early swallowing intervention can improve patients' swallowing function and short-term quality of life. We can only summarize the basic consensus of the studies on early swallowing intervention, and rigorous trials are needed in the future.

KEYWORDS

deglutition disorders, free flap reconstruction, mouth neoplasms, swallowing intervention, systematic review

1 | INTRODUCTION

The oral cavity is the most common subsite of head and neck cancer. According to the GLOBOCAN 2020 estimates from the International Agency for Research on Cancer, the annual number of new cases diagnosed was 377,713 with 177,757 annual mortalities from oral cancer,[1] which has become an increasingly important public health problem.[2,3] Radical resection with microvascular free flap reconstruction is a standard treatment for these patients.[4] However, radical surgery may seriously destroy swallowing structure, and the free flap is denervated after transplantation. Therefore, the residual structure of oral cavity can not maintain normal swallowing function for most postoperative patients. The incidence of dysphagia can be as high as 98%[5,6] on the seventh postoperative day, which seriously affects patients' quality of life.[7,8]

Previous studies have proved that swallowing training improves the swallowing function for oral cancer patients after surgery.[9–11] In recent years, more studies have advocated that early swallowing intervention should be used as a means to improve functional outcomes for the patients after surgery and before radiotherapy, thus certain effects can be achieved.[12,13] Early postoperative swallowing intervention helps patients recover faster and better in swallowing function, thus facilitates safe oral intake and adequate nutrition,[6,14,15] which is significant

for patients' subsequent treatment and quality of life.[5,9,16] Different from local resection of oral cancer, there are risks of complications at the recipient site, such as wound dehiscence, bleeding, fistula, thrombosis, and even flap failure in the early postoperative period after free flap reconstruction.[17] Premature or inappropriate swallowing intervention may increase the above risks, but the best recovery opportunity may be missed if the intervention starts too late.

To date, several studies have evaluated the effect of early swallowing intervention on such patients,[6,15,18,19] but a comprehensive integration of the evidence is still lacking. Therefore, the purpose of this systematic review is to summarize the state of current literature and evaluate evidence for timing, methods, and effects of early intervention in oral cancer patients after free flap reconstruction. It would provide a basis for the evidence-based practice of early swallowing rehabilitation after free flap reconstruction for oral cancer.

2 | METHODS

We followed the guidelines from the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement in this study. The systematic review was registered a priori with the International Prospective Register of Systematic Reviews (Prospero registration number: CRD42022358660).

2.1 | Search strategy

A comprehensive search was conducted in nine databases: PubMed, Embase, Web of Science, The Cochrane Library, CINAHL, CNKI, Wanfang, China Science and Technology Journal Database and SinoMed. The publication date of the articles included from inception to August 2022. Based on the principle of PICO, the main search terms included oral cancer, dysphagia and swallowing rehabilitation by using a combination of subject words and keywords. The corresponding search strategy is formulated for each database. The specific search strategies for all databases are shown in Appendix A. In addition, we also reviewed the reference lists of all included studies to find more relevant studies.

2.2 | Inclusion and exclusion criteria

2.2.1 | Inclusion criteria

Studies were included if they met the following criteria:

- Study design: randomized controlled trial (RCT) or quasi-experimental study;
- Population: the subjects were primary oral cancer, or oral cancer accounted for more than 20% of head and neck cancer; the surgery method was free flap reconstruction; age ≥ 18 years old;
- Intervention: all rehabilitation training that could improve swallowing function;
- Comparator: blank control, standard of care, routine nursing or other therapies;
- Outcome:
  Primary outcome measures: tools used to evaluate swallowing function and tested for reliability and validity, including Water Swallow Test (WST), Eating Assessment Tool-10 (EAT-10), Functional Oral Intake Scale (FOIS), and Penetration-Aspiration Score (PAS) combining with Videofluoroscopic Swallowing Study (VFSS), etc;
  Secondary outcome measures: the incidence of postoperative adverse events or postoperative complications, including aspiration, pulmonary infection, weight loss, wound dehiscence, fistula, etc; quality of life assessment, including MD Anderson Dysphagia Inventory (MDADI), University of Washington Quality of Life scale (UW-QoL), Functional Assessment of Cancer Therapy-Head and Neck (FACT-H&N), Swallowing-related Quality of Life Scale (SWAL-QoL), etc;
- Language: English or Chinese

2.2.2 | Exclusion criteria

Studies were excluded if they met the following criteria:

- The paper type: research protocol or conference abstracts;
- Unable to obtain the full text or repeated publication;
- The start time of postoperative swallowing intervention was longer than 1 month after surgery, or the start time was during postoperative radiotherapy or chemotherapy;
- Swallowing function was not involved in the outcome measures

2.3 | Study selection

All the retrieved studies were imported into EndNote 20, and two reviewers independently screened the literature. Irrelevant studies were removed by reviewing the titles and abstracts of the literature. Then by reading the full text, the studies were determined according to the inclusion and exclusion criteria. Any discrepancy in literature screening results were settled through discussion or consultation with the third reviewer.

2.4 | Quality assessment

Two researchers independently evaluated the quality of the literature. The evaluation tool used was the JBI Critical Appraisal Tools for randomized controlled trials and quasi-experimental studies.[20] Any disagreements were discussed with a third reviewer until full consensus was achieved.

2.5 | Data extraction

Two reviewers independently used self-designed unified tables to extract data, including author, publication year, type of study design, sample size, primary site of tumor, tumor staging, gender, age, intervention method, intervention start time, dosage, duration, etc. In case of inconsistency of extracted information, the final content of literature data extraction shall be determined through discussion.

2.6 | Statistical analysis

Studies were grouped according to the outcome measures and assessment time of the included studies. RevMan5.4 was used for the meta-analysis. Effect sizes were expressed using mean difference (MD) or standard mean difference (SMD), and the results were presented as point estimates and 95% confidence intervals (CI). Heterogeneity was estimated using chi-square test. When $p \geq 0.1$ and $I^2 < 50\%$, homogeneity was considered to exist, and a fixed-effect model was used to calculate effect sizes. Otherwise, when $p < 0.1$ and $I^2 \geq 50\%$, heterogeneity was considered to exist, and a random effect model was used.

3 | RESULTS

3.1 | Results of the search

A total of 5757 articles were retrieved from the database. By importing EndNote 20, 1829 duplicates were automatically removed and 488 duplicates were manually removed, leaving 3440 studies. 87 studies remained after removal of irrelevant studies by reviewing the titles and abstracts. After further reading the full text and evaluating the quality of literature, eight papers were finally included. Among them, five papers were in English[6,15,18,21,22] and three were in Chinese,[19,23,24] including one master's degree thesis.[24] No other studies were included by manual search of the

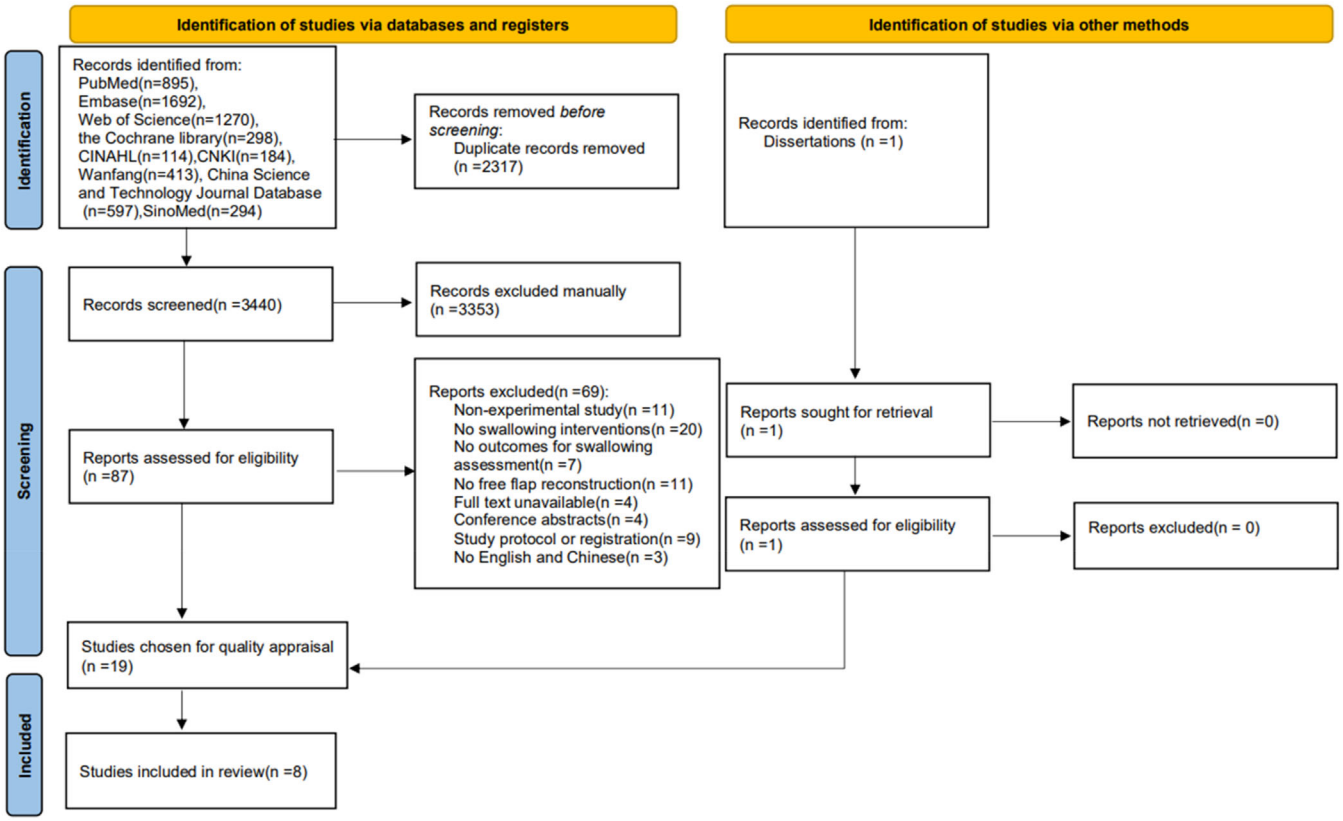


FIGURE 1 Flow diagram for the literature selection. [Color figure can be viewed at wileyonlinelibrary.com]

reference lists of the included literature. The literature selection process is shown in Figure 1.

3.2 | Study characteristics and outcome measures

Among the eight literatures (three were RCTs[6,18,24] and five were quasi-experimental studies[15,19,21–23]), a total of 610 oral cancer patients were involved in this study, including 468 males (76.7%) and 142 females (23.3%), with an average age of 51.0 to 61.5 years. Four studies focused only on tongue cancer patients,[19,21–23] three studies included patients with various subsite of oral cancer,[6,15,18] and one only included patients with soft palate cancer.[24] All studies reported the number of patients with different tumor stages, including 223 patients in the early stage (stage I or II), 380 patients in the late stage (stage III or IV) and seven patients in uncertain tumor stage (see Table 1).

The outcome indicators mainly included swallowing function, quality of life and postoperative complications(see Table 2). The most commonly used swallowing function assessment tools were WST ($n = 3$)[19,22,24] and EAT-10 ($n = 2$).[15,23] Two studies used instruments to assess swallowing function and safety by PAS.[15,18] Quality of life was assessed in five studies.[6,15,19,21,23] The most commonly used tool was MDADI ($n = 2$),[15,21] which was used to assess short-term and long-term effects. Only one study focused on the rate of postoperative complications, including aspiration, aspiration pneumonia and other indicators.[19] Two studies reported the changes in postoperative body weight.[6,15] All studies did not report postoperative local complications.

3.3 | Intervention Characteristics

Among the eight included studies, six were concurrent controlled trials[6,18,19,21,23,24] and two were before and

TABLE 1 Study characteristics

Authour (year)	Type of study	Sample size	Primary site of tumor	Tongue resection	Tumor staging	Mean age (range)	Gender (M/F)
Bai et al. (2022)	Q	total:100 EG:50 CG:50	Tongue:100	≥50%:51 <50%:49	I:13, II:22 III:46 IV:19	EG:57.27 (43 ~ 81) CG:59.23 (39 ~ 79)	EG:36/14 CG:33/17
Huang et al. (2017)	Q	Total:134 EG:67 CG:67	Tongue:134	≥50%:69 <50%:65	I:10, II:45 III:58 IV:21	61.5 (36 ~ 74)	96/38
Zhang et al. (2022)	R	Total:68 EG:34 CG:34	Tongue:15, Buccal:11, Palate:11, Mouth floor:5, Upper gum or Maxilla:8 Lower gum or Mandible:18	NR	I:3, II:21 III:18 IV:19 Unclear:7	EG:51.00 CG:54.32	EG:23/11 CG:22/12
Mao et al. (2019)	R	Total:50 EG:25 CG:25	Soft palate:50	NA	I:20, II:17 III:8 IV:5	55.8 (26 ~ 78)	EG:20/5 CG:16/9
Zhen et al. (2012)	Q	Total:46 EG:23 CG:23	Tongue:46	≥50%:19 <50%:27	I:6, II:10 III:21 IV:9	EG:60.52 CG:57.47	EG:17/6 CG:14/9
Hsiang et al. (2019)	R	Total:50 EG:25 CG:25	Lip:1, Tongue:17, Buccal:14, Hard palate:2, Mouth floor:2, Upper gum:3, Lower gum:3 Retromolar trigone:2, tonsil:4	NR	I:10, II:9 III:10 IV:21	EG:55.6 (43 ~ 70) CG:56.7 (40 ~ 76)	EG:24/1 CG:24/1
Tseng et al. (2021)	Q	EG:104	Lip:1, Tongue:23, Buccal:48, Hard palate:2, Mouth floor:4, Gingiva:13 Retromolar trigone:4, Multiple sites:9	NR	II:5, III:8 IV:91	EG:56.99	EG:100/4
Zhang et al. (2014)	Q	EG:58	Tongue:58	≥50%:28 <50%:30	I:9, II:23 III:21 IV:5	EG:56.6 (40 ~ 81)	EG:43/15

Abbreviations: CG, control group; EG, experimental group; NR, not report; NA, not available; R, RCT; Q, quasi-experimental study.

TABLE 2 Characteristics of the intervention.

Authour (year)	Interventions		Intervention model	Time point of intervention	Dosage	Intervenor	Outcomes and measurement	Conclusions
	Experimental group	Control group						
Bai et al. (2022)	a + b + c + d	Standard of care	Periodic training First stage: b + d Second stage: a + c	First stage: 5 days after surgery Second stage: 10 ~ 14 days after surgery	10 repetitions each time, 3 ~ 4 times/d; 1 months	Nurses	WST, SWAL-QoL, Complication Rate: aspiration symptoms, pneumonia, eating choke	Improvement in WST score, QoL score and adverse event rate; The rate of adverse events was 20% in the control group and 6% in the experimental group
Huang et al. (2017)	a + b + c + d	Blank control	Continuous training	10 days after surgery	20 ~ 30 min each time, 1 ~ 2 times/d; 10 days	—	EAT-10, FACT-H&N	Improvement in EAT-10 score and the total score of FACT-H&N
Zhang et al. (2022)	a + b + d	Standard of care +d	Continuous training	6 days after surgery	20 ~ 30 min each time, 2 times/d; 10 days	Rehabilita -tion nurses	MASA-OC, UW-QoL, Time of Feeding Tube Removal, Weight Loss Rate	Improvement in the total MASA-OC score and QoL score; Shortening the retention time of nasogastric tube and reducing the weight loss rate
Mao et al. (2019)	a + c + e	Standard of care	Periodic training First stage: c + e Second stage: a	First stage: 14 days after surgery Second stage: 6 weeks after surgery	c:5 min each time, 3 ~ 5 times/d e:15 ~ 30 min each time, 2 times/d a:30 ~ 45 min/d 4 months	Nurses + SLP	WST, Masticatory Function Assessment, Chinese Speech Intelligibility Word List, MIO	Improvement in WST score, mouth opening and speech function; No significant difference in masticatory function
Zhen et al. (2012)	a + b + c + d	Blank control	Continuous training	14 ~ 21 days after surgery	30 min each time, Daily; 2 weeks	Rehabilita -tion nurses	MDADI	Improvement in the total score of the MDADI
Hsiang et al. (2019)	a + c	c	Continuous training	Within 3 weeks after surgery	10 repetitions each time, 3 times/d; 3 months	head and neck clinical nurse specialists	MBSS+PAS	Improvement in PAS score and oropharyngeal residue of thickened liquid
Tseng et al. (2021)	a + c + d	—	Continuous training	7 days after surgery	20-30 min each time, 2 times/d; 24 months	SLP	FOIS, EAT-10 FEES+PAS, MDADI, Weight, Diet Level: IDDSI	A trend of recovery in FOIS from 1 month, and in weight and MDADI from 3 months

TABLE 2 (Continued)

Author (year)	Interventions: Experimental group	Interventions: Control group	Intervention model	Time point of intervention	Dosage	Intervenor	Outcomes and measurement	Conclusions
Zhang et al. (2014)	a + b + c + d	—	Continuous training	—	30 min each time, daily; 10 days	Rehabilitation nurses	WST, SDS	Improvement in WST score and SDS score after swallowing intervention than before

Abbreviations: a, oral exercise training; b, oral sensory stimulation; c, compensation strategies; d, protecting airway maneuvers; e, speech training, standard of care: the routine postoperative care for oral cancer patients without swallowing intervention, such as free flap monitoring, oral care, nasogastric tube care, dietary guidance, etc. FACT-H&N, Functional Assessment of Cancer Therapy-Head and Neck; FEES, Flexible Endoscopic Examination of Swallowing; EAT-10, Eating Assessment Tool-10; FOIS, Functional Oral Intake Scale; IDDSI, The International Dysphagia Diet Standardization Initiative; MASA-OC, Mann Assessment of Swallowing Ability-Oral Cancer; MBSS, Modified Barium Swallow Study; MIO, Maximal Interincisal Opening; MDADI, MD Anderson Dysphagia Inventory; PAS, Penetration-Aspiration Score; SDS, The Zung Self-Rating Depression Scale; SWAL-QoL, Swallowing-related Quality of Life Scale; SLP, speech-language pathologist; UW-QoL, University of Washington Quality of Life scale; WST, Water Swallow Test.

after self-controlled trials.[15,22] Most of the swallowing intervention protocols were developed by rehabilitation therapists, speech-language pathologist (SLP) and/or clinical experts, and were mainly administered or monitored by trained nurses ($n = 6$).[6,18,19,21,22,24]

The intervention start time varies from the fifth postoperative day to 3 weeks after surgery.[18] Six studies started the intervention within 1 to 2 weeks after surgery,[6,15,19,21,23,24] and one study[22] did not report the intervention start time. According to the start time, the intervention mode was divided into periodic training and continuous training. Periodic training refers to dividing the intervention period into multiple periods, and different training methods are selected for different periods, while continuous training means that the same training method is used throughout the study period. Two studies used the periodic training model,[19,24] and six studies used the continuous training model.[6,15,18,21–23] Although intervention start time and training methods were not uniform, the majority of studies suggested that oral exercise training should be implemented at least 1 week after surgery, and the free flap and wound healing should be evaluated before intervention.

In addition, the dosage and duration of each intervention varied among the studies (see Table 2).

3.4 | Swallowing training methods

In terms of swallowing training methods, most studies ($n = 7$) combined multiple training methods. Oral exercise training was used in all studies, followed by compensatory strategies, oral sensory stimulation and protecting airway maneuvers. Only one study combined speech training[24] (see Table 3).

3.4.1 | Oral exercise training

All of the eight included studies used oral exercise training, seven studies involved tongue range of motion training or tongue muscle strength training,[6,15,18,19,21–23] and four studies reported specific methods.[6,15,18,19] Six studies involved range of motion exercise or coordinated training of lip, cheek, jaw and laryngeal,[6,15,18,21–23] but only three studies described the implementation process of training in detail.[6,15,18] One study used a mouth opener for passive training.[24]

3.4.2 | Oral sensory stimulation

Five studies combined the training with oral sensory training,[6,19,21–23] mainly with temperature stimulation

TABLE 3 Specific swallowing training methods list.

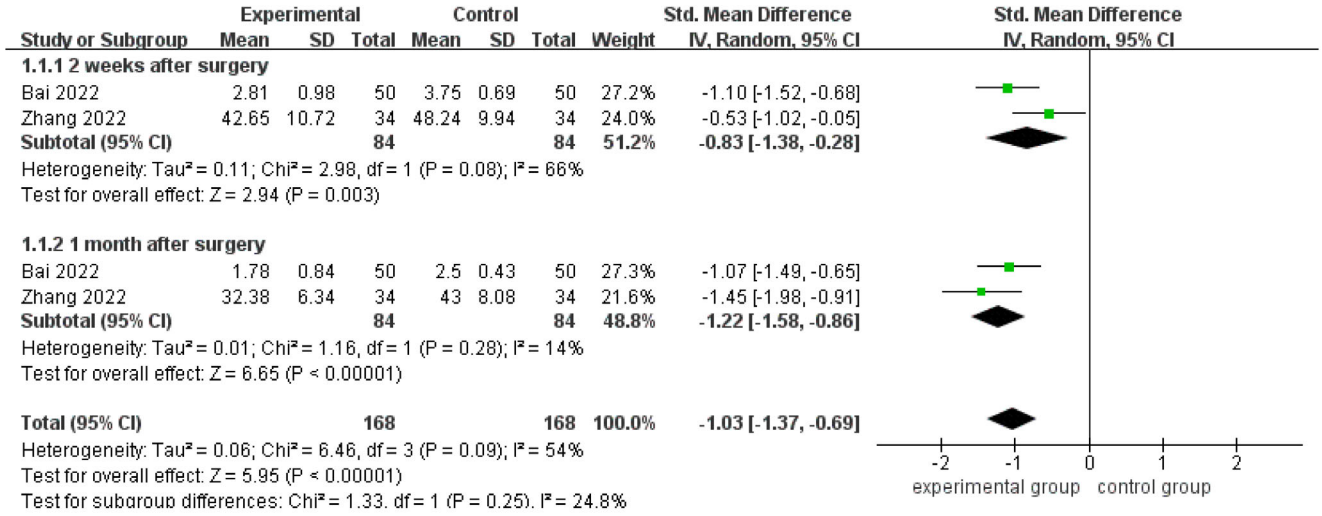
Actual check ticks (✓) = interventions present		Bai et al. (2022)	Huang et al. (2017)	Zhang et al. (2022)	Mao et al. (2019)	Zhen et al. (2012)	Hsiang et al. (2019)	Tseng et al. (2021)	Zhang et al. (2014)	Rate (%)
Oral exercise training	Tongue exercises	✓	✓	✓		✓	✓	✓	✓	87.5
	Lip exercises		✓	✓		✓	✓	✓	✓	75.0
	Cheek exercises			✓		✓		✓	✓	50.0
	Jaw movement			✓	✓		✓	✓		50.0
	Laryngeal exercises					✓			✓	25.0
	Masako maneuver							✓		12.5
Oral sensory stimulation	Cold stimulation	✓	US							12.5
	Thermal stimulation					✓			✓	25.0
	Cold-Acid stimulation			✓						12.5
	Vibration training			✓						12.5
	Air pulse stimulation			✓						12.5
Compensation strategies	Proper swallowing positions	✓			✓	✓			✓	50.0
	Bite-Size adjustment	✓	✓							25.0
	Diet modifications		✓			✓		✓	✓	50.0
Protective airway maneuvers	Supraglottic swallow	✓	✓	✓		✓		✓	✓	75.0
	Mendelsohn maneuvers					✓		✓	✓	37.5
Speech training					✓					12.5
Total number of interventions		5	6	7	3	9	3	8	9	

Abbreviation: US, unspecific method.

(two thermal stimulation,[21,22] one cold stimulation[19] and one cold-acid stimulation[6]). Two studies reported the location, tool and dosage in detail,[6,19] but there were differences on stimulation site. Bai et al.[19] advocated stimulating the residual structure, while Zhang et al.[6] stimulated both the residual structure and free flap. One study combined three different sensory stimulation methods: cold-acid stimulation, vibration training and air pulse stimulation.[6] One study did not report specific sensory stimulation method.[23]

3.4.3 | Compensation strategies

Six studies used compensation strategies,[6,15,18,19,21–24] which mainly included proper swallowing position, diet modification and bite-size adjustment. In one study, compensation strategies were used in both the control and experimental groups.[18] Another study conducted proper food textures according to the IDDSI framework,[15] while the other studies did not report the method of food modification. In addition, Bai et al.[19] suggested that early



The data of Zhang was reverse-scored to be consistent with the direction of other studies.

FIGURE 2 Effects of swallowing intervention on swallowing function after surgery. The data of Zhang was reverse-scored to be consistent with the direction of other studies. [Color figure can be viewed at wileyonlinelibrary.com]

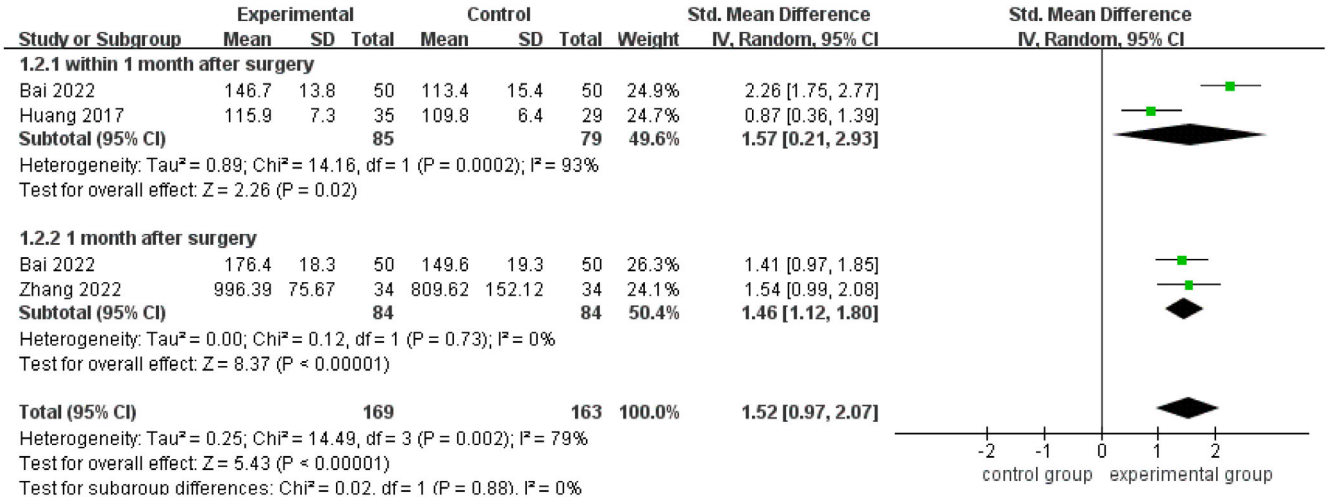


FIGURE 3 Effects of swallowing intervention on the quality of life. [Color figure can be viewed at wileyonlinelibrary.com]

postoperative compensatory training could promote the safety of patients' oral feeding, and improve their feeding capacity through direct feeding training.

3.4.4 | Protecting airway maneuvers

In terms of protecting airway maneuvers, six studies used supraglottic swallow,[6,15,19,21–23] among which three studies combined Mendelsohn maneuvers.[15,21,22]

3.4.5 | Speech training

One study implemented speech training at the second week after surgery, and developed a individual training after evaluation by SLP,[24] mainly including vowel and consonant pronunciation training and dialogue training.

3.5 | Effects of intervention

3.5.1 | Effects of swallowing intervention on swallowing function after surgery

Because of the differences in study design, outcome measures and follow-up time, only two studies were included to calculate effect size,[6,19] which were both concurrent controlled trials and chose non-instrumental assessment to evaluate swallowing outcomes. We evaluated the effect of swallowing intervention at 2 weeks and 1 month after

surgery. A total of 336 patients were enrolled. It may be heterogeneous due to the differences in training methods and duration at 2 weeks after surgery ($p = 0.08$, $I^2 = 66\%$). By using the random effect model, the results showed that swallowing training could improve the swallowing function of patients in the experimental group than those in the control group at 2 weeks and 1 month after surgery (SMD = −1.03, 95%CI [−1.37, −0.69], $Z = 5.95$, $p < 0.01$) (see Figure 2).

3.5.2 | Effects of swallowing intervention on the quality of life

Three studies were conducted to analyze the effect of swallowing intervention on the quality of life for patients in the short term (≤1 month after surgery).[6,19,23] A total of 332 patients were enrolled. We divided the results into two subgroups according to the assessment time. The random effect model was used because of total homogeneity ($p = 0.002$, $I^2 = 79\%$). The heterogeneity may result from different intervention dosages and assessment time in the first subgroup. The results showed that the postoperative quality of life in the experimental group was significantly better than that in the control group (SMD = 1.52, 95%CI [0.97, 2.07], $Z = 5.43$, $p < 0.01$) (see Figure 3).

3.6 | Risk of bias in included studies

The three RCTs included were randomized by computer-generated random numbers.[6,18,24] Only one study had allocation concealment.[18] The risk of implementation bias was high because practical and ethical considerations made it difficult to blind the interveners and subjects. A blinding method was applied to the outcome assessors in one study[18] (see Table A1). Among the five quasi-experimental studies included in this study, two were before and after self-controlled trials[15,22] and three were concurrent controlled trials.[19,21,23] The literature quality was generally well (see Table A2).

4 | DISCUSSION

With the development of microsurgical technology, microvascular free-tissue transfer has become the standard in reconstruction for oral cancer patients.[4] However, compared with the damage to the swallowing organs caused by radical surgery, the free flap reconstruction for swallowing function is limited. As a result, postoperative swallowing rehabilitation is still an important problem for these patients.[25,26] At present, the benefits of early swallowing intervention are supported by a large amount of evidence,[12,13] such as reducing the degree of aspiration, penetration and pharyngeal residue,[27] shortening the indwelling time of nasogastric tube,[28] and improving patients' nutritional status[14] and quality of life.[29] It is also beneficial in patients with oral cancer after free flap reconstruction.[6,15,18,22] Due to the particularity of the surgery, premature or inappropriate swallowing intervention may increase the risk of postoperative complications, but starting too late may lead to missing the best time to recover. Therefore, the training method and the intervention start time for such patients are difficult to implement in clinical work.

We reviewed the swallowing training methods and found that the majority of the studies were based on oral exercise training, combined with compensatory strategies, oral sensory stimulation and protecting airway maneuvers. Oral exercise training mainly involves the exercise of muscle strength and range of motion for swallowing organs. Among the included studies, tongue motor training was the most commonly used method, which included range exercises such as tongue extension, retraction, lifting, and rotation, as well as resistance training of tongue muscles, because the functions of tongue bulk and the base of tongue are crucial to the completion of the stages of oral transit and pharyngeal.[30] Due to the inevitable pulling of surgical wounds or free flap in the process of exercise, many studies recommended that the healing of surgical wounds be evaluated before training.[6,19,23,24] However, most of them are evaluated by clinical observation combined with experience, such as whether the free flap had complications, whether the skin and mucosa sutures were removed or absorbed, etc. No standardized assessment method has been formed. The oral sensory training mainly stimulates the superficial sense of the palate arch, tongue base, tongue body, cheek and other area inside the mouth by temperature or acid, so as to improve the sensitivity of the oropharynx to the food ball and the coordination of swallowing movement.[31] Besides, it has little effect on the local wound or flap tissue. Protecting airway maneuvers mainly reduces the risk of aspiration by controlling the timing of airway closure and increasing the range of motion and strength of the pharynx, larynx and other structures of mouth.

For the training modes, two studies implemented the intervention in phases.[19,24] In the early stage, patients were given non-exercise training, and oral motor training was carried out in the later stage after the flap status was stable. Other studies used a continuous training model. However, due to the few included studies and the differences in protocols, it is difficult for us to compare and obtain the most suitable training model for the patients.

In the future, it can be considered to compare the effects under different training modes.

As for the intervention start time, most studies started within 1 to 2 weeks after surgery. The earliest intervention time was on the fifth postoperative day,[19] but only oral sensory stimulation, airway maneuvers protection and compensatory strategies were implemented. The vast majority of included studies did not start oral exercise training until at least 1 week after surgery. It is clinically recognized that the postoperative complications after free flap reconstruction peak at 48 ~ 72 h.[32,33] Normally, free flap monitoring lasts 5 to 7 days after surgery, during which time the intraoral mucosal tissue has been epithelialized.[34] Therefore, most studies considered oral exercise after the monitoring period or after the suture removal of skin and mucosal wounds. For tongue cancer patients, tongue motor training mainly refers to active training. Active training is exercise training completed by patients independently, while passive training mostly involves the use of tools such as tongue blade or tongue suction device to assist training. Therefore, compared with passive training, active training can help patients master the training intensity better, and avoid secondary injury caused by excessive strength. Moreover, tongue motor training is mainly performed after 10 to 14 days postoperatively for such patients. On the one hand, this may be related to the premature stretching and curling movement of tongue bulk after tongue reconstruction, which may increase the risk of wound cracking caused by continuous tension of anastomosis. On the other hand, at 10–14 days after surgery, the wound has entered the maturation and remodeling phase, which can accept a certain force of traction and pressure, and appropriate exercise can prevent muscle fibrosis.[35]

Our study mainly analyzed the effect of early swallowing intervention on postoperative swallowing function and quality of life. Despite the methodological limitations, we chose the same type of study design and (or) the same measurement time. The study found that swallowing training can effectively improve the postoperative swallowing function and short-term quality of life for such patients, which is consistent with the findings of Zhang et al.[9] and Ye et al.[36] However, the existing evidence on the risk of early swallowing intervention was insufficient. Only one study reported the rate of postoperative complications such as aspiration symptoms and pneumonia, while there were no reports of postoperative local complications such as wound dehiscence, fistula formation and so on. The lack of data regarding this makes it hard to interpret the overall potential benefit for early intervention. It has been shown that patient adherence has a significant impact on swallowing outcomes. Most studies used a variety of methods to promote the patient adherence, such as a rehabilitation manual,[19] supervision and guidance through telemedicine,[6,18,24] and a patient self-reported exercise diary.[13] However, only one study reported the results of patient adherence. Therefore, it is difficult to statistical analyze the actual dose effect of swallowing training. We suggest that future studies should report the actual training amount of patients in as much detail as possible, so as to facilitate the replication of subsequent studies and the development of clinical practice.

In addition, we found that in many studies, trained nurses (mostly nurses specializing in rehabilitation) were involved in the guidance or supervision of patients' swallowing training, which was consistent with the result of systematic review by Banda et al.[10] In fact, SLP shortages are worse in less developed regions than in most developed countries. Therefore, a multidisciplinary swallowing rehabilitation program involving nurses may make up for this problem to some extent.

4.1 | Limitations

There are some limitations in this study. Firstly, only eight studies were included in this study, which may be due to the fact that most of the current studies on swallowing intervention focus on the period of radiotherapy. Besides, only eight studies that explicitly reported free flap reconstruction were included because of non-standard reports or unreported surgical methods. Secondly, on account of the differences in tumor sites, swallowing training dosages and methods among the studies, there is certain heterogeneity among the studies in the meta-analysis. Therefore, it is necessary to be cautious in the generalization of the results. We believe that more high-quality, large-sample, multicenter randomized controlled trials should be conducted to explore the dose effect of swallowing training and the optimal mode of training, and provide specific and reproducible evidence for clinical practice. Postoperative complications on free flap as the indicators of studies would be included to further explore and determine the comprehensive benefits and risks of early swallowing training.

5 | CONCLUSION

Early swallowing intervention can improve the swallowing function and short-term quality of life for oral cancer patients after free flap reconstruction. In some practice models, published models support the critical role that rehabilitation nurses can play in swallowing training. By reviewing the available evidence, it was found that swallowing intervention time usually started

within 1–2 weeks after surgery, and the intervention methods was mainly oral exercise training, combined with a variety of training methods. Oral exercise training was implemented at least 1 week after surgery, and it was emphasized that surgical wound and free flap should be evaluated before training. However, due to the differences in various of study protocols, outcome measures and the lack of reporting of postoperative complication outcomes, it is still difficult to determine the specific optimal timing and methods for swallowing rehabilitation in such patients, and rigorous trials are needed in the future.

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DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created in this study.

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APPENDIX A: SEARCH STRATEGIS

Database: PubMed

#1 "mouth neoplasm*"[Title/Abstract] OR "oral neoplasm*"[Title/Abstract] OR "mouth cancer*"[Title/Abstract] OR "oral cancer*"[Title/Abstract] OR "mouth tumor*"[Title/Abstract] OR "oral tumor*"[Title/Abstract] OR "oral cavity cancer*"[Title/Abstract] OR "mouth neoplasms"[MeSH Terms] OR "mouth carcinoma*"[Title/Abstract] OR "mouth squamous cell carcinoma*"[Title/Abstract] OR "oral carcinoma*"[Title/Abstract] OR "oral squamous cell carcinoma*"[Title/Abstract] OR "head and neck neoplasm*"[Title/Abstract] OR "head and neck cancer*"[Title/Abstract] OR "head and neck tumor*"[Title/Abstract] OR "tongue neoplasms"[MeSH Terms] OR "tongue neoplasm*"[Title/Abstract] OR "tongue cancer*"[Title/Abstract] OR "tongue tumor*"[Title/Abstract] OR "tongue carcinoma*"[Title/Abstract] OR "tongue squamous cell carcinoma*"[Title/Abstract]

#2 "deglutition"[MeSH Terms] OR "deglutition*"[Title/Abstract] OR "swallowing*"[Title/Abstract] OR "deglutition disorders"[MeSH Terms] OR "deglutition disorder*"[Title/Abstract] OR "swallowing disorder*"[Title/Abstract] OR "swallowing difficult*"[Title/Abstract] OR "Dysphagia"[Title/Abstract] OR "swallowing dysfunction "[Title/Abstract] OR "Oropharyngeal Dysphagia"[Title/Abstract] OR "deglutition difficulty"[Title/Abstract]

#3 "swallowing function"[Title/Abstract] OR "swallowing exercise*"[Title/Abstract] OR "swallowing training"[Title/Abstract] OR "Oral Sensory Stimulation"[Title/Abstract] OR "oral exercise*"[Title/Abstract] OR "swallowing intervention"[Title/Abstract] OR "swallowing rehabilitation"[Title/Abstract] OR "swallowing therapy"[Title/Abstract] OR "swallow therapy"[Title/Abstract]

#4 "Rehabilitation"[MeSH Terms] OR "Rehabilitation"[Title/Abstract] OR "function training"[Title/Abstract] OR "exercise*"[Title/Abstract] OR "intervention*"[Title/Abstract] OR "Rehabilitation Nursing"[MeSH Terms] OR "rehabilitation nursing*"[Title/Abstract] OR "Aftercare"[MeSH Terms] OR "After Care"[Title/Abstract] OR "after treatment*"[Title/Abstract] OR "follow up care*"[Title/Abstract]

#5 "Radiotherapy"[Title] OR "radiation*"[Title] OR "chemoradio*"[Title]

#6 #3 OR #4

#7 #1 AND #2 AND #6

#8 #7 NOT #4

Database:Embase

#1 'mouth tumor'/exp OR 'mouth tumor*':ti,ab,kw OR 'oral neoplasm*':ti,ab,kw OR 'mouth neoplasm*':ti,ab,kw OR 'mouth cancer'/exp OR 'mouth cancer*':ti,ab,kw OR 'oral cancer*':ti,ab,kw OR 'oral cavity cancer*':ti,ab,kw OR 'mouth carcinoma*':ti,ab,kw OR 'mouth squamous cell carcinoma*':ti,ab,kw OR 'oral carcinoma*':ti,ab,kw OR 'oral squamous cell carcinoma*':ti,ab,kw OR 'head and neck neoplasm*':ti,ab,kw OR 'head and neck tumor*':ti,ab,kw OR 'head and neck cancer*':ti,ab,kw OR 'tongue tumor'/exp OR 'tongue cancer'/exp OR 'tongue tumor*':ti,ab,kw OR 'tongue neoplasm*':ti,ab,kw OR 'tongue cancer*':ti,ab,kw OR 'tongue carcinoma*':ti,ab,kw OR 'tongue squamous cell carcinoma*':ti,ab,kw

#2 'swallowing'/exp OR 'deglutition':ti,ab,kw OR 'swallowing*':ti,ab,kw OR 'dysphagia'/exp OR 'dysphagia':ti,ab,kw OR 'deglutition disorder*':ti,ab,kw OR 'swallowing disorder*':ti,ab,kw OR 'swallowing difficult*':ti,ab,kw OR 'deglutition difficulty':ti,ab,kw OR 'swallowing dysfunction ':ti,ab,kw OR 'Oropharyngeal Dysphagia':ti,ab,kw

#3 'swallowing function':ti,ab,kw OR 'swallowing exercise*':ti,ab,kw OR 'swallowing training':ti,ab,kw OR 'Oral Sensory Stimulation':ti,ab,kw OR 'oral exercise*':ti,ab,kw OR 'swallowing intervention':ti,ab,kw OR 'swallowing rehabilitation':ti,ab,kw OR 'swallowing therapy':ti,ab,kw OR 'swallow therapy':ti,ab,kw

#4 'Rehabilitation'/exp OR 'Rehabilitation':ti,ab,kw OR 'function training':ti,ab,kw OR 'exercise*':ti,ab,kw OR 'intervention'/exp OR 'intervention*':ti,ab,kw OR 'Rehabilitation Nursing'/exp OR 'Rehabilitation Nursing':ti,ab,kw OR 'Aftercare'/exp OR 'Aftercare':ti,ab,kw OR 'after treatment*':ti,ab,kw OR 'follow up care*':ti,ab,kw

#5 'Radiotherapy':ti OR 'Radiation*':ti OR 'Chemoradio*':ti

#6 #3 OR #4

#7 #1 AND #2 AND #6

#8 #7 NOT #5

#9 ([article]/lim OR [article in press]/lim OR [short survey]/lim OR [preprint]/lim) AND [english]/lim AND [humans]/lim

#10 #8AND#9

Database: web of science

#1:TS=("mouth neoplasm*" OR "oral neoplasm*" OR "mouth cancer*" OR "oral cancer*" OR "mouth tumor*" OR "oral tumor*" OR "oral cavity cancer*" OR "mouth carcinoma*" OR "mouth squamous cell carcinoma*" OR "oral carcinoma*" OR "oral squamous cell carcinoma*" OR "head and neck neoplasms" OR "head and neck neoplasm*" OR "head and neck cancer*" OR "head and neck tumor*" OR "tongue neoplasms" OR "tongue neoplasm*" OR "tongue cancer*" OR "tongue tumor*" OR "tongue carcinoma*" OR "tongue squamous cell carcinoma*")

#2:TS=(“Deglutition” OR “Deglutition*” OR “Swallowing*” OR “Deglutition Disorders” OR "Deglutition Disorder*" OR “Swallowing Disorder*” OR “Swallowing Difficult*” OR “Dysphagia” OR "Oropharyngeal

Dysphagia" OR "swallowing dysfunction" OR "deglutition difficulty")

#3:TS=("swallowing function" OR "swallowing exercise*" OR "swallowing training" OR "Oral Sensory Stimulation" OR "oral exercise*" OR "swallowing intervention" OR "swallowing rehabilitation" OR "swallowing therapy" OR "swallow therapy")

#4:TS=("Rehabilitation" OR "function training" OR "exercise*" OR "intervention*" OR "rehabilitation nursing*" OR "Aftercare" OR "after treatment*" OR "follow up care*")

#5: TI=("Radiotherapy" OR "radiation*" OR "chemoradio*")

#6: #3 OR #4

#7: #1 AND #2 AND #6

#8: #7 NOT #5

Database: the Cochrane Library

#1:Mesh descriptor:[Mouth Neoplasms]explode all trees

#2:("mouth neoplasm*" OR "oral neoplasm*" OR "mouth cancer*" OR "oral cancer*" OR "mouth tumor*" OR "oral tumor*" OR "oral cavity cancer*" OR "mouth carcinoma*" OR "mouth squamous cell carcinoma*" OR "oral carcinoma*" OR "oral squamous cell carcinoma*" OR "head and neck neoplasms" OR "head and neck neoplasm*" OR "head and neck cancer*" OR "head and neck tumor*" OR "tongue neoplasms" OR "tongue neoplasm*" OR "tongue cancer*" OR "tongue tumor*" OR "tongue carcinoma*" OR "tongue squamous cell carcinoma*"):ti,ab,kw

#3:#1 OR #2

#4: Mesh descriptor:[Deglutition]explode all trees

#5: Mesh descriptor:[Deglutition Disorders]explode all trees

#6:(“Deglutition” OR “Deglutition*” OR “Swallowing*” OR “Deglutition Disorders” OR "Deglutition Disorder*" OR “Swallowing Disorder*” OR “Swallowing Difficult*” OR “Dysphagia” OR "Oropharyngeal Dysphagia" OR "swallowing dysfunction" OR "deglutition difficulty"):ti,ab,kw

#7:#4 OR #5 OR #6

#8: Mesh descriptor:[Rehabilitation]explode all trees

#9: Mesh descriptor:[Rehabilitation Nursing]explode all trees

#10: Mesh descriptor:[Aftercare]explode all trees

#11:("swallowing function" OR "swallowing exercise*" OR "swallowing training" OR "Oral Sensory Stimulation" OR "oral exercise*" OR "swallowing intervention" OR "swallowing rehabilitation" OR "swallowing therapy" OR "swallow therapy"): ti,ab,kw

#12:("Rehabilitation" OR "function training" OR "exercise*" OR "intervention*" OR "rehabilitation nursing*" OR "Aftercare" OR "after treatment*" OR "follow up care*"): ti,ab,kw

#13: #8 OR #9 OR #10 OR #11 OR #12

#14:#3 AND #7 AND #13

Database: CINAHL Plus with Full Text

#1: AB "mouth neoplasm*" OR "oral neoplasm*" OR "mouth cancer*" OR "oral cancer*" OR "mouth tumor*" OR "oral tumor*" OR "oral cavity cancer*" OR "mouth carcinoma*" OR "mouth squamous cell carcinoma*" OR "oral carcinoma*" OR "oral squamous cell carcinoma*" OR "head and neck neoplasms" OR "head and neck neoplasm*" OR "head and neck cancer*" OR "head and neck tumor*" OR "tongue neoplasms" OR "tongue neoplasm*" OR "tongue cancer*" OR "tongue tumor*" OR "tongue carcinoma*" OR "tongue squamous cell carcinoma*"

#2: AB “Deglutition” OR “Deglutition*” OR “Swallowing*” OR “Deglutition Disorders” OR "Deglutition Disorder*" OR “Swallowing Disorder*” OR “Swallowing Difficult*” OR “Dysphagia” OR "Oropharyngeal Dysphagia" OR "swallowing dysfunction" OR "deglutition difficulty"

#3: AB ("swallowing function" OR "swallowing exercise*" OR "swallowing training" OR "Oral Sensory Stimulation" OR "oral exercise*" OR "swallowing intervention" OR "swallowing rehabilitation" OR "swallowing therapy" OR "swallow therapy") OR AB ("Rehabilitation" OR "function training" OR "exercise*" OR "intervention*" OR "rehabilitation nursing*" OR "Aftercare" OR "after treatment*" OR "follow up care*")

#4: #1 AND #2 AND #3

#5: TI "Radiotherapy" OR "radiation*" OR "chemoradio*"

#6: #4 NOT #5

Database: CNKI (同义词拓展)

SU=('头颈癌' + '头颈部肿瘤' + '头颈肿瘤' + '头颈部恶性肿瘤' + '口腔癌' + '口腔肿瘤' + '舌癌' + '口腔鳞状细胞癌') AND SU=('吞咽' + '吞咽障碍' + '吞咽困难' + '进食' + '进食困难') AND SU=('吞咽功能' + '吞咽康复' + '吞咽训练' + '吞咽运动' + '口腔运动训练' + '口腔感觉训练' + '吞咽运动' + '口腔运动训练' + '口腔感觉训练' + '代偿训练' + '代偿方式' + '训练' + '康复' + '干预' + '吞咽治疗')

Database: Wanfang (主题词拓展，勾选期刊论文和学位论文)

主题:("头颈癌" OR "头颈部肿瘤" OR "头颈肿瘤" OR "头颈部恶性肿瘤" OR "口腔癌" OR "口腔肿瘤" OR "舌癌" OR "口腔鳞状细胞癌") and 主题:("吞咽" OR "吞咽障碍" OR "吞咽困难" OR "进食" OR "进食困难") and 主题:("吞咽功能" OR "吞咽康复" OR "吞咽训练" OR "吞咽运动" OR "口腔运动训练" OR "口腔感觉训练" OR "代偿训练" OR "代偿方法" OR "训练" OR "康复" OR "干预" OR "吞咽治疗")

TABLE A1 Risk of bias summary of RCTs included in the review

Authour (year)	1	2	3	4	5	6	7	8	9	10	11	12	13
Zhang et al. (2022)	Yes	Yes	Yes	No	No	No	Yes	Yes	NA	Yes	Yes	Yes	Yes
Mao et al. (2019)	Yes	Unclear	Yes	No	No	No	Yes	Yes	NA	Yes	Yes	Yes	Yes
Hsiang et al. (2019)	Yes	Unclear	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: 1: Was true randomization used for assignment of participants to treatment groups? 2: Was allocation to treatment groups concealed? 3: Were treatment groups similar at the baseline? 4: Were participants blind to treatment assignment? 5: Were those delivering treatment blind to treatment assignment? 6: Were outcomes assessors blind to treatment assignment? 7: Were treatment groups treated identically other than the intervention of interest? 8: Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analyzed? 9: Were participants analyzed in the groups to which they were randomized? 10: Were outcomes measured in the same way for treatment groups? 11: Were outcomes measured in a reliable way? 12: Was appropriate statistical analysis used? 13: Was the trial design appropriate, and any deviations from the standard RCT design (individual randomization, parallel groups) accounted for in the conduct and analysis of the trial?
Abbreviation: NA, not applicable.

TABLE A2 Risk of bias summary of quasi-experimental studies included in the review

Authour (year)	1	2	3	4	5	6	7	8	9
Bai et al. (2022)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Huang et al. (2017)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Zhen et al. (2012)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Tseng et al. (2021)	Yes	NA	NA	No	Yes	Yes	Yes	Yes	Yes
Zhang et al. (2014)	Yes	NA	NA	No	Yes	Yes	Yes	Yes	Yes

Note: 1 Is it clear in the study what is the 'cause' and what is the 'effect' (i.e. there is no confusion about which variable comes first)? 2: Were the participants included in any comparisons? 3: Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest? 4: Was there a control group? 5: Were there multiple measurements of the outcome both pre and post intervention/exposure? 6: Was follow-up complete and, if not, were differences between groups in terms of their follow-up adequately described and analyzed? 7: Were the outcomes of participants included in any comparisons measured in the same way? 8: Were outcomes measured in a reliable way? 9: Was appropriate statistical analysis used?
Abbreviation: NA, not applicable.

Database: China Science and Technology Journal Database

R=(头颈癌 OR 头颈部肿瘤 OR 头颈肿瘤 OR 头颈部恶性肿瘤 OR 口腔癌 OR 口腔肿瘤 OR 舌癌 OR 口腔鳞状细胞癌) AND R=(吞咽 OR 吞咽障碍 OR 吞咽困难 OR 进食 OR 进食困难) AND R=(吞咽功能 OR 吞咽康复 OR 吞咽训练 OR 吞咽运动 OR 口腔运动训练 OR 口腔感觉训练 OR 代偿训练 OR 代偿方法 OR 训练 OR 康复 OR 干预 OR 吞咽治疗)

Database: SinoMed

(("头颈癌"[摘要:智能] OR "头颈部肿瘤"[摘要:智能] OR "头颈肿瘤"[摘要:智能] OR "头颈部恶性肿瘤"[摘要:智能] OR "口腔癌"[摘要:智能] OR "口腔肿瘤"[摘要:智能] OR "舌癌"[摘要:智能] OR "口腔鳞状细胞癌"[摘要:智能])) AND (("吞咽功能"[摘要:智能] OR "吞咽康复"[摘要:智能] OR "吞咽训练"[摘要:智能] OR "吞咽运动"[摘要:智能] OR "口腔运动训练"[摘要:智能] OR "口腔感觉训练"[摘要:智能] OR "代偿训练"[摘要:智能] OR "代偿方法"[摘要:智能] OR "训练"[摘要:智能] OR "康复"[摘要:智能] OR "干预"[摘要:智能] OR "吞咽治疗"[摘要:智能])) AND (("吞咽"[摘要:智能] OR "吞咽障碍"[摘要:智能] OR "吞咽困难"[摘要:智能] OR "进食"[摘要:智能] OR "进食困难"[摘要:智能]))