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Summary of the Best Evidence for Treatment and Management of Drooling in Children with Cerebral Palsy Based on Evidence-Based Approach

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Abstract: *Objective*: Literature review on the treatment and management of drooling in children with cerebral palsy was conducted. The literature was screened, evaluated, and compiled into an optimal evidence table to provide evidence-based reference for the treatment and management of drooling in children with cerebral palsy. *Methods*: A systematic search was conducted in the following databases for relevant evidence on the treatment and management of drooling in children with cerebral palsy: BMJ Best Practice, CINAHL, Cochrane Library, Clinical Trials, Embase, PubMed, UpToDate, Web of Science, GIN (Global Institution for Instruction), NGC (National Center for Health and Care Excellence), NICE (National Institute for Health and Care Excellence), JBI (Journal of the Institute of Evidence-Based Healthcare), Ontario Registered Nurses Association, SIGN (Scotland Institute of Instructions), Med live, CNKI (China National Knowledge Infrastructure), Chinese Medical Association, China Biomedical Research Center, Wan fang Data, and VIP (VIP Database). The literature types included guidelines, expert consensus, best clinical practice, evidence summaries, systematic reviews and randomized controlled trials. The search period was from database inception to July 30, 2025. All evidence related to the treatment and management of drooling in children with cerebral palsy was compiled, identified, and summarized to form the best evidence system. *Results*: A total of 22 articles were included, comprising 5 guidelines, 9 systematic reviews and systematic summaries, 3 expert consensus statements, and 5 randomized controlled trials. The optimal evidence framework contained 28 pieces of best evidence covering 10 aspects, including multidisciplinary team collaboration, comprehensive step-by-step assessment, overall treatment principles, behavioral therapy, physical therapy, drug therapy, intraglandular botulinum toxin injection, surgical treatment, radiotherapy, and dynamic follow-up. *Conclusion*: The best evidence

summarized in this study is scientific and systematic. Healthcare professionals can use this best evidence to develop targeted interventions to alleviate drooling symptoms, reduce complications, and improve treatment efficacy and quality of life in children with cerebral palsy. Furthermore, when developing treatment plans, it is crucial to comprehensively consider the specific clinical context of the child with cerebral palsy, treatment effectiveness, follow-up adjustment results, and the wishes of both the child and caregivers.

Keywords: Cerebral palsy; Neurodevelopmental disorder; Drooling; Saliva; Evidence summary

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1. Introduction

Cerebral palsy is a disorder characterized by abnormal muscle tone, abnormal posture, and movement. Its neonatal incidence is 0.15%, which is even higher in low- and middle-income countries and regions [1]. Patients with CP or neurodevelopmental disorders often exhibit varying degrees of oral motor dysfunction or dysphagia, with drooling being one of the most common complications [2]. Studies have shown that more than 40% of CP children over four years of age experience drooling [3]. Drooling can be classified into three types: anterior drooling, posterior drooling, and combined drooling. Anterior drooling is defined as unintentional loss of saliva in the oral cavity , occurring in approximately 44% of CP children [4,5]. Posterior drooling refers to saliva overflowing from the base of the tongue into the pharynx, leading to saliva accumulation, choking, recurrent pulmonary infections, and other life-threatening conditions, which require urgent intervention. And combined drooling can present with symptoms of both anterior and posterior drooling [6,7]. Long-term drooling can cause skin ulcers, difficulty eating, perioral maceration, choking, and other problems, which not only affect a child's physical health but also lead to low self-esteem, social isolation, and embarrassment. This creates numerous problems for the child and their family's daily life and mental well-being, increasing the burden of care and severely impacting the quality of life for both the individual and the family [8,9]. Therefore, it is crucial to take effective measures to manage drooling in children with cerebral palsy. In recent years, numerous studies have been conducted domestically and internationally on treatment protocols for drooling, yet the available evidence remains fragmented. This study systematically reviewed and synthesized the best available evidence based on evidence-based protocols, aiming to provide a scientific and standardized basis for healthcare professionals to formulate evidence-informed management measures. In addition, the series of complications caused by drooling described in this study, such as skin problems around the mouth and chin, oral health problems, and even psychological and social barriers, are all caused by Anterior drooling or Combination. so, all the best evidence summarized in this study is for these two types of drooling.

2. Materials and methods

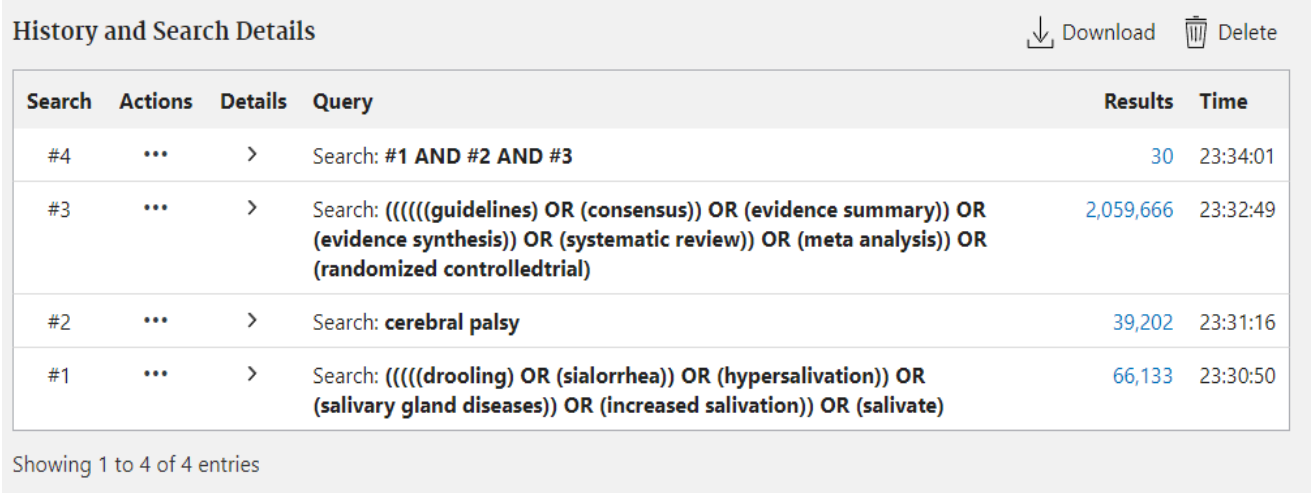
2.1. Evidence-based problem identification

The research question was defined based on the PIPOST model. The study population (P) consisted of children aged 0–14 years with cerebral palsy and drooling symptoms. The intervention (I) included measures and methods to alleviate drooling symptoms. The evidence applicator (P) was healthcare professionals or rehabilitation therapists in pediatrics or pediatric rehabilitation departments. The outcome measures (O) included the rate and

volume of drooling, aspiration or choking, and quality of life. The evidence application setting (S) was hospitals, pediatric or pediatric rehabilitation wards, or households. The evidence types (T) included clinical decision-making, evidence summaries, guidelines, best practices, expert consensus, systematic reviews, and randomized controlled trials.

2.2. Retrieval strategy

Using the 6S Model of the Evidence Pyramid, we conducted a top-down evidence search. For drooling, we used the following English search terms: drooling, drool, sialorrhea, hyper salivation, salivary gland diseases, salivate, salivation, salivation disorder, clear salivation, increased salivation, excessive salivation, saliva spillage. For cerebral palsy, we used the following English search terms: cerebral palsy, brain paralysis, spastic cerebral palsy. The search was conducted in databases including BMJ Best Practice, CINAHL, Cochrane Library, Clinical Trials, Embase, PubMed, UpToDate, Web of Science, Guidelines International Network (GIN), and the National Guideline Clearinghouse. Databases such as the National Geospatial Database (NGC), the website of the National Institute for Health and Clinical Excellence (NICE) in the UK, the Joanna Briggs Institute (JBI) Evidence-Based Healthcare Centre database in Australia, the Registered Nurses' Association of Ontario (RNAO) website in Canada, and the Scottish Intercollegiate Guide-lines Network (SIGN) in Scotland. Using the Chinese search terms "drooling/drooling disorder/drooling disease/saliva flow/salivary disorders/saliva clearance/salivary hypersecretion/salivary overflow/cerebral palsy drooling/childhood cerebral palsy drooling" to retrieve relevant evidence from databases and websites such as Yimaitong, China CNKI, Chinese Medical Association website, China Biomedical Literature, Wanfang database, and VIP database. The search language was Chinese and English. The search time frame was from the database establishment to July 30,2025. Taking the PubMed database as an example, the search strategy is shown in **Figure 1**.



History and Search Details

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Search	Actions	Details	Query	Results	Time
#4	•••	›	Search: **#1 AND #2 AND #3**	30	23:34:01
#3	•••	›	Search: **((((((guidelines) OR (consensus)) OR (evidence summary)) OR (evidence synthesis)) OR (systematic review)) OR (meta analysis)) OR (randomized controlledtrial)**	2,059,666	23:32:49
#2	•••	›	Search: **cerebral palsy**	39,202	23:31:16
#1	•••	›	Search: **(((((drooling) OR (sialorrhea)) OR (hypersalivation)) OR (salivary gland diseases)) OR (increased salivation)) OR (salivate)**	66,133	23:30:50

Showing 1 to 4 of 4 entries

Figure 1. PubMed literature retrieval strategy.

2.3. Literature inclusion and exclusion criteria

2.3.1. Inclusion criteria

(1) Study subjects were children aged 0–14 years with cerebral palsy and drooling;

(2) The primary research content focused on alleviating or improving drooling symptoms in children with cerebral palsy;

(3) The types of literature involved in the research include clinical decision-making, evidence summaries, guidelines, best practices, expert consensus, systematic reviews, and randomized controlled trials.

2.3.2. Exclusion criteria

(1) Literature that was duplicated across different databases;
(2) Literature with low quality assessment scores;
(3) Non-Chinese/English literature;
(4) Literature for which full-text access was unavailable.

2.4. Literature quality evaluation

The JBI Guidelines for Research & Evaluation Instrument (AGREE II) was used to evaluate the guidelines, with each item scored on a 1–7 scale. The JBI Systematic Reviews of Methodological Quality (SRM) tool was applied to systematic review literature, comprising 11 items, each assessed with "yes, no, unclear, or uncertain". The Cochrane Collaboration's Risk of Bias Assessment for Randomized Controlled Trials (RCTs) tool was utilized for 7 items, requiring judgments of low, high, or unclear bias risk for each item. The JBI Methodological Quality Assessment for Expert Opinions and Professional Consensus (MEPAC) tool was employed for 6 items, each evaluated with "yes, no, unclear, or uncertain" [10]. Two researchers with evidence-based methodology training independently assessed the literature quality, followed by cross-evaluation. In case of disagreement, a third expert with senior professional title and systematic evidence-based training participated in discussions to reach a consensus.

2.5. Evidence extraction and integration

The two researchers independently extracted and consolidated relevant evidence from the literature, with a third researcher conducting semantic and content verification. When cross-cultural or adaptive differences arise, a senior evidence-based expert in the team should conduct a re-evaluation and propose a team-wide analysis and discussion until a consensus is reached. The extracted information mainly includes the publication time, source, type, and topic of the literature, as well as the best relevant evidence. The best approach to evidence compilation follows these principles: evidence that is consistent and complementary is merged based on content and logic; mutually exclusive evidence is merged according to the principles of high quality, high grade, and most recently published [10].

Firstly, the included studies were pre-classified using the Australian JBI Pre-Classification and Recommendation Level System (2014 version), categorizing evidence into levels 1–5, with level 1 being the highest and level 5 the lowest. Then, based on the system's recommendation strength grading principles and guided by the JBI FAME structure (feasibility, appropriateness, clinical significance, and effectiveness of evidence), the recommendation strength for each item was determined to be either Level A (strong recommendation) or Level B (weak recommendation). Evidence derived from evidence summaries and guidelines was directly graded according to their original evidence levels. Secondly, based on the evidence downgrading and upgrading principles of the GRADE system (Grades of Recommendations Assessment, Development and Evaluation, GRADE) (5 factors that reduce quality and 3 factors that increase quality), the included literature was further upgraded or downgraded. Finally, the best evidence compiled by our team was assessed for its level of evidence.

3. Results

3.1. Literature screening process and general characteristics of included studies

This study initially retrieved 644 articles, of which 413 were retained after deduplication. Following review of titles and abstracts, 345 articles were excluded for being unrelated to the topic, and 68 articles were preliminarily included. After full-text reading, 22 articles were ultimately selected. The literature retrieval and screening process is illustrated in **Figure 2**, and the general characteristics of the included articles are presented in **Table 1**.

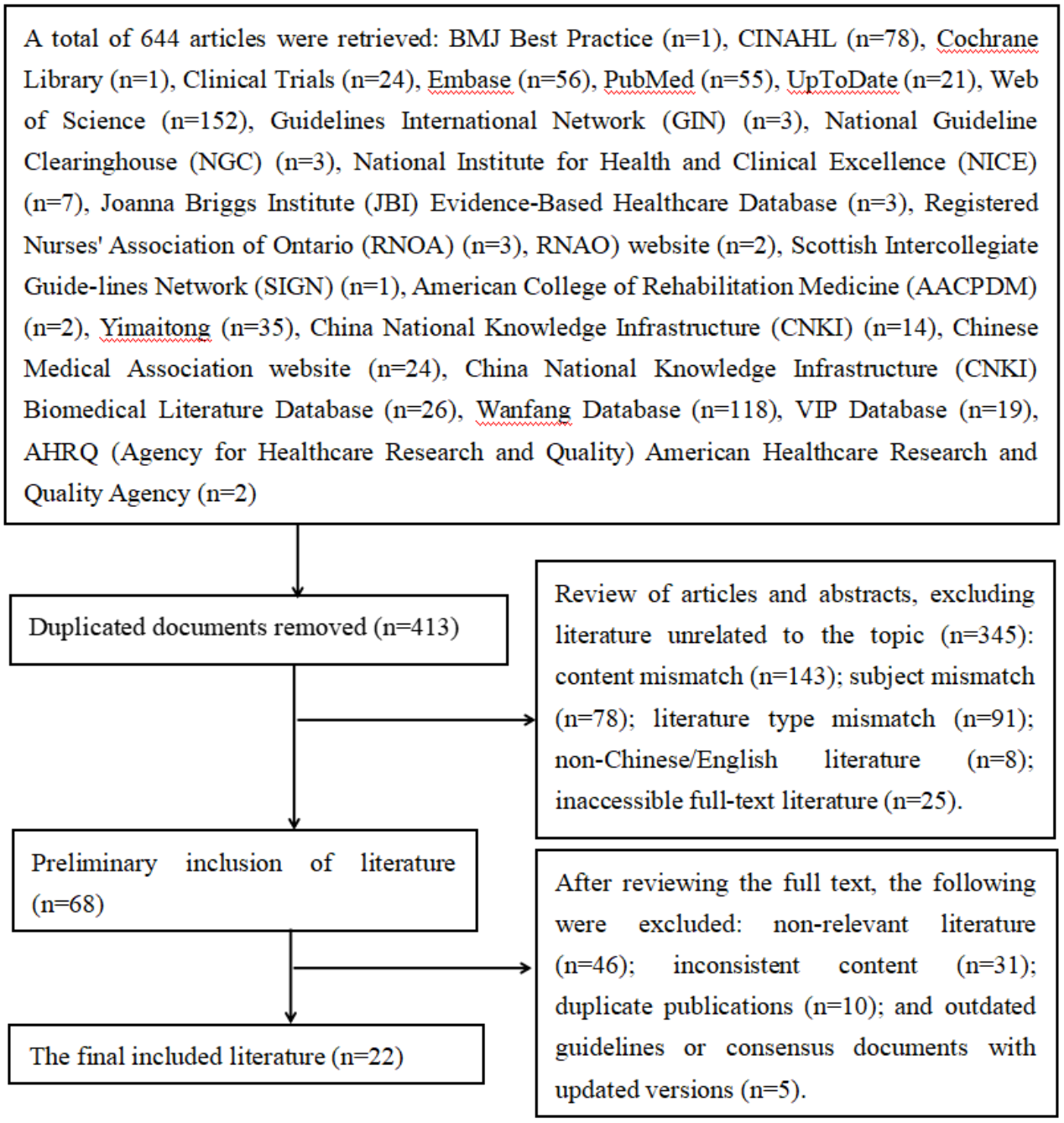

Figure 2. Literature retrieval and screening process.

Table 1. General characteristics of the included literature (n = 22)

No.	Included literature	Year of publication	Source of literature	Type of literature	Literature topics
1	Gibson N et al. [11]	2021	Medlive Guide Network	Guidelines	Prevention and Management of Respiratory Diseases in Children with Cerebral Palsy
2	NICE [12]	2017	NICE	Guidelines	Assessment and Management of Cerebral Palsy in Children Under 25 Years of Age
3	Zhang Jiankui et al. [13]	2022	Medlive Guide Network	Guidelines	Interpretation of Core Content in the Rehabilitation Guidelines for Cerebral Palsy (2022)
4	Bekkers S et al. [14]	2020	PubMed	randomized controlled trial	Cost-effectiveness of botulinum toxin A and surgical treatment for sialorrhea
5	Bekkers S et al. [15]	2021	PubMed	randomized controlled trial	Surgical treatment and botulinum toxin A injections are used to reduce drooling.
6	Xu Kaisou et al. [16]	2020	CNKI	specialist consensus	Rehabilitation recommendations for children with cerebral palsy who experience motor impairments.
7	Rodwell K et al. [17]	2012	PubMed	systematic review	Treatment of Sialorrhea in Children with Cerebral Palsy and Neurodevelopmental Disorders by Botulinum Toxin Injection
8	Lam KTT et al. [18]	2024	PubMed	systematic review	The effect of elastic therapeutic patches on reducing drooling in children
9	Walshe M et al. [2]	2012	Cochrane Library	systematic review	Intervention Measures for drooling in Children with Cerebral Palsy
10	Oad H et al. [19]	2024	PubMed	systematic assessment	Treatment of drooling in Children with Botulinum Toxin A (BoNT-A) Injection
11	Dias BLS et al. [20]	2017	PubMed	randomized controlled trial	Sublingual atropine sulfate is used to treat drooling in children with cerebral palsy.
12	Hung SA et al. [21]	2021	PubMed	systems assessment	Treatment of drooling in Children with Botulinum Toxin A (BoNT-A) Injection
13	Banzato A et al. [22]	2022	PubMed	systematic review	Efficacy Evaluation of Functional Chewing Training and Standard Treatment in Children with Cerebral Palsy
14	Fan Qiongli et al. [23]	2020	CNKI	randomized controlled trial	A prospective randomized controlled study on the treatment of oral motor dysfunction in children with cerebral palsy by chewing function training
15	Fayoux P et al. [24]	2024	PubMed	randomized controlled trial	Application of 320ug/mL Glycine Bromide in Children with Severe drooling and Neurological Diseases
16	Orriens LB et al. [25]	2024	PubMed	specialist consensus	Interdisciplinary Assessment and Treatment of Sialorrhea in Children
17	NICE [26]	2017	NICE	Guidelines	Oral glycyl bromide is used to treat severe drooling in children with chronic neurological disorders.
18	NICE [27]	2019	NICE	Guidelines	Treatment for chronic sialorrhea by Botulinum Toxin A (BoNT-A) Injection
19	Sforza E et al. [28]	2022	PubMed	systematic review	Outcome Measurement of Sialorrhea in Children
20	Bai Zirong et al. [29]	2024	CNKI	systems assessment	A systematic review of the efficacy of intrasalivary gland injection of botulinum toxin in the treatment of drooling in cerebral palsy.
21	Meningaud JP et al. [30]	2006	Upto date	systems assessment	Etiology and Treatment of Sialorrhea
22	Riva A et al. [31]	2022	PubMed	specialist consensus	The Influence and Management of Sialorrhea in Children with Neurological Disorders

3.2. Quality evaluation results of included literature

A total of 5 guidelines were included, with the quality assessment results of the literature presented in **Table 2**; 9 systematic reviews and meta-analyses were included, with the quality assessment results of the literature presented in **Table 3**; 3 expert consensus articles were included, with the quality assessment results of the literature presented in **Table 4**; and 5 randomized controlled trials (RCTs) were included, with the quality assessment results of the literature presented in **Table 5**.

Table 2. Quality assessment results of inclusion criteria (n = 5)

Include in guidelines	Standardized percentage (%) of scores in each field						≥ 60% of fields	≥ 30% and < 60% of the fields	< 30% number of fields	Overall quality of guideline	Recommended level
	Scope and Purpose	Participant	Rigor of formulation	Clarity of expression	Practicability	Editor independence					
Gibson N et al.	84.37	89.78	85.44	87.47	90.12	86.78	6	0	0	6	A
NICE	100	93.54	88.79	85.41	92.31	84.42	6	0	0	6	A
Li Xiaojie et al.	88.78	85.32	83.54	79.84	94.28	80.54	6	0	0	6	A
NICE	95.78	81.25	90.21	89.68	85.11	91.20	6	0	0	6	A
NICE	100	92.30	93.04	92.33	88.78	93.20	6	0	0	6	A

Note: NICE is the National Institute for Health and Care Excellence

Table 3. Quality assessment results of included systematic reviews (n = 9)

Inclusion in systematic review	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Rodwell K et al.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
LamKTT class	yes	yes	yes	yes	yes	NK	yes	yes	yes	yes	yes
Walshe M et al.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
OadH class	yes	yes	yes	yes	yes	yes	yes	yes	NK	yes	yes
HungSA class	yes	yes	yes	yes	yes	yes	NK	yes	yes	yes	yes
Banzato A et al.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Sforza E et al.	yes	yes	yes	yes	yes	yes	yes	yes	NK	yes	yes
Bai Zirong et al.	yes	yes	yes	yes	NK	yes	yes	yes	yes	yes	yes
Meningaud JP et al.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

Note: (1) Is the proposed evidence-based question clearly defined? (2) Are the inclusion criteria for the literature appropriate? (3) Is the search strategy used appropriate? (4) Is the source of the research papers appropriate? (5) Are the quality criteria for the literature appropriate? (6) Was the literature quality assessment independently completed by two or more evaluators? (7) Were measures taken to minimize errors during data extraction? (8) Is the method of synthesizing/ merging studies accurate? (9) Was potential publication bias assessed? (10) Were recommendations for policies and/or practices supported by reported data? (11) Were suggestions for further research directions provided?

Table 4. Quality assessment results of expert consensus (n = 3)

Included expert consensus	(1)	(2)	(3)	(4)	(5)	(6)
Xu Kaishou et al.	yes	yes	yes	yes	yes	NK
Orriens LB et al.	yes	yes	yes	yes	NK	NK
RivaA class	yes	yes	yes	yes	yes	NK

Note: (1) Is the source of the viewpoint clearly cited? (2) Does the viewpoint originate from influential experts in the field? (3) Does the proposed viewpoint center on the interests of the relevant population? (4) Are the conclusions based on analytical results, and is the expression of the viewpoint logically sound? (5) Are other literature references included? (6) Does the proposed viewpoint contradict previous literature?

Table 5. Quality assessment results of included randomized controlled trials (n = 5)

Inclusion in randomized controlled trials	(1)	(2)	(3)	(4)	(5)	(6)	(7)	Include
Bekkers S et al.	low	low	low	low	Gao	low	low	yes
Bekkers S et al.	low	NK	low	low	NK	low	low	yes
Dias BLS et al.	low	low	NK	low	low	low	low	yes
Fan Qiongli et al.	low	low	low	NK	low	low	NK	yes
Fayoux P et al.	low	NK	low	low	low	low	low	yes

Note: (1) generation of random sequences; (2) concealment of randomization assignments; (3) blinding of study subjects and interveners; (4) blinding of outcome assessors; (5) completeness of outcome data (loss to follow-up); (6) possibility of selective reporting of study results; (7) other sources of bias.

3.3. Summary of evidence

This study synthesized 28 pieces of evidence from 10 aspects, including multidisciplinary team collaboration, comprehensive stepwise evaluation, general treatment principles, behavioral therapy, physical therapy, pharmacotherapy, intradermal botulinum toxin injection, surgical treatment, radiotherapy, and dynamic follow-up. See **Table 6**.

Table 6. Summary of best available evidence for drooling management in children with cerebral palsy

Classification of evidence	Content of evidence	Evidence grade	Evidence recommendation strength
Multidisciplinary team collaboration	1. It is recommended to adopt a multidisciplinary team collaboration model, with team members including pediatric neurologists, pediatricians, plastic surgeons, speech therapists, otolaryngologists, occupational therapists, psychologists, nurses, and teachers. When necessary, consultation with specialized dentists, physical therapists, dietitians, or gastroenterologists should be sought [2,11,25].	1a	A
Comprehensive stepwise evaluation	2. Conduct professional evaluation. It is recommended to first perform a professional assessment, including detailed medical history collection, physical examination, age of onset, developmental age and dental age, posture, medication use, reflux, duration of disease course, triggering factors, accompanying symptoms, developmental history, medication use, family history, perinatal experience, as well as evaluations of children's learning ability, self-management skills, social functioning (e.g., interaction with social environments, self-awareness, coping with negative reactions to drooling), and oral motor assessment [2,12,25].	1a	A

Table 6 (Continued)

Classification of evidence	Content of evidence	Evidence grade	Evidence recommendation strength
	3. Determine the type of drooling. It is recommended to first identify the type of drooling in children (Anterior drooling, Posterior drooling, or both), as Posterior drooling may be life-threatening and should be prioritized over Anterior drooling [2,25]. For children under 4 years of age, the use of percentile scores from the Drooling Rating Inventory for Infants and Preschoolers (DRIPS) is recommended to quantify the presence of pathological drooling.	1a	A
	4. Quantifying the severity, frequency, and actual impact of drooling symptoms. The assessment of Anterior drooling employs a combination of semi-objective and subjective methods [28,30]. The 5-minute Drooling Questionnaire (DQ5A) has been validated as an effective and reliable tool for objectively measuring drooling frequency in children with moderate to severe cerebral palsy [18,28]. The Drooling Impact Scale (DIS), French version of the Drooling Impact Scale (DIS-F), and the Modified Drooling Scale are currently the only assessment tools with responsive data, capable of effectively detecting clinically significant changes over time, serving as reliable tools for evaluating drooling severity and social acceptability [28]. The assessment of daily wet wipe usage frequency, however, is subject to debate due to the reliance on subjective judgment for replacement decisions, and its reliability remains questionable [18].	1b	A
	5. Assess the impact on children and/or caregivers. This includes evaluating the degree of impact on their lives, satisfaction with the intervention measures, and improvements in quality of life and mental health [2,28]. It is recommended to use assessment tools that comply with psychological measurement standards.	1c	B
	6. Assess the treatment preferences of the child and caregiver and establish treatment goals. Consider comprehensively the type and severity of drooling, the child's age, cognitive level, oral motor skills, self-awareness, and communication abilities, and involve the child or caregiver in the decision-making process to determine the optimal treatment plan [2,25].	1c	B
Principle of treatment	7. There is no clear consensus on safe and effective interventions for treating drooling in children with cerebral palsy, making it difficult to determine which intervention is the safest and most effective [2]. No authoritative accounts directly linking these interventions have been identified.	1b	B
	8. Methods to improve drooling typically include behavioral therapy, physical therapy, orthodontic appliances, pharmacotherapy, botulinum toxin injections for salivary glands, surgical procedures [2,14,15], radiotherapy and acupuncture [2,30]. It is recommended to prioritize less invasive interventions such as behavioral and pharmacological therapies, which can serve as preparatory steps for invasive treatments or as supplementary options for subsequent therapies [25]. Only then should more invasive treatments, such as botulinum toxin injections or surgical procedures, be considered [14,15].	1b	A
	9. The treatment plan is formulated progressively based on the patient's needs, adhering to the principle of "conservative treatment as the priority, drug intervention as the secondary option, and surgical treatment as the last resort" [2].	1a	A
	10. For children with a developmental age ≥ 6 years, guidance should be provided for daily self-management of salivation to enhance intrinsic control over saliva secretion. For children ≤ 12 years of age, pharmacological treatment is more preferred over surgical intervention for salivary secretion control. When a child presents for the first time with an age > 12 years and a developmental age < 6 years, surgical treatment may be the most appropriate therapeutic option [25].	1a	B

Table 6 (Continued)

Classification of evidence	Content of evidence	Evidence grade	Evidence recommendation strength
Behavior therapy	11. Behavioral therapies include swallowing exercises, head posture control, mouth closure, self-regulation of drooling, oral function training, speech therapy, swallowing coordination training, chewing function training, dysarthria treatment, and feeding therapy, all aimed at enhancing target behaviors and improving self-control of drooling [2,13,22,23,29]. Regardless of the treatment approach, intermittent oral sensory-motor therapy is recommended as an adjunctive intervention.	1b	B
Naturopathy	12. For interventions such as physical therapy, the primary goals are to improve lip and jaw closure function, enhance tongue control, reduce tongue thrusting, regulate muscle tone, and restore facial and oral sensory functions. Key approaches include: neurostimulation therapy, electromyographic biofeedback training, elastic therapy patches, acupuncture, massage, and oral sucking training. It is important to avoid forceful or forceful kneading of the face in children with cerebral palsy, and to promptly change bibs, etc [13,18,29,30].	1b	B
	13. The recommended elastic therapeutic taping combined with speech therapist-guided oral training techniques can rapidly improve oral motor skills and salivation control, with superior efficacy compared to monotherapy. The application of taping is more effective when applied to the orbicularis Oris muscle, suprasternal thyroids muscle, or both. The tension of the taping should be set at approximately 40%, with a duration ranging from 2.5 hours to 3 days. Prior to implementation, the physician should evaluate individual factors such as the patient's clinical diagnosis, allergy history, oral motor function, swallowing function, available resources, and needs to determine whether to adopt this therapy and the specific implementation method, including the application site, duration, and course length [18].	1a	A
	14. Orthodontic appliances (such as the Exeter lip sensor, palatal training appliance, Innsbruck sensory-motor activation regulator, and Castillo-Morales appliance) should be selected based on their shape, wearing position, and required duration, and are often used in combination with oral motor therapy [2].	1b	A
Medication	15. Prior to medication administration, it is essential to accurately assess the indications and contraindications for drug use, evaluate potential influencing factors such as medication history, reflux, dental issues, etc, and administer drugs individually, starting with a low dose and gradually increasing it. Regularly review the efficacy, tolerability, and side effects of all medications used for salivary control [12,26,29].	1b	A
	16. When botulinum toxin therapy is ineffective or contraindicated, anticholinergic drugs are recommended under the guidance of a specialist [12,15]. Administration routes include oral, transdermal, sublingual, intramuscular injection, and nebulization inhalation. Commonly used drugs include atropine sulfate, glucobromide, scopolamine, and trihexyphenidyl [20,24].	1a	B
	17. Bromocyclidine (administered orally or via enteric catheter), horseradish cholinesterase inhibitor (HRCI) transdermal formulation, or trihexyphenidyl hydrochloride are recommended. Bromocyclidine should be administered at least 1 hour before meals or 2 hours after meals, or at fixed times before or after meals. The dosage should be calculated based on the child's body weight, with an initial dose of 16 μg per kilogram of body weight, administered three times daily. The dose should be increased weekly over 4 weeks and continued at the maximum tolerated dose for another 4 weeks unless adverse reactions occur. For bromocyclidine bromide, the oral solution should be initiated at 0.02 mg/kg and increased by 0.02 mg/kg weekly until the optimal tolerated dose is reached, with a maximum dose of 1.5–3.0 mg, administered three times daily. After reaching the optimal dose level, the same drug and dose should be continued for a total of 8 weeks [24,26].	1a	A

Table 6 (Continued)

Classification of evidence	Content of evidence	Evidence grade	Evidence recommendation strength
	18. Anticholinergic drugs show limited efficacy in patients with severe drooling and are associated with a high incidence of adverse reactions during treatment. They are only suitable for short-term use in children, with close monitoring of adverse reactions [30]. Adverse reactions are often dose-dependent and difficult to assess in children with disabilities. Treatment should be discontinued if constipation, urinary retention, or pneumonia occurs.	1a	A
Intradermal injection of botulinum toxin for treatment	19. There is no unified or standardized approach regarding the selection of botulinum toxin types, optimal injection sites, solution preparation, ideal therapeutic doses, dilution ratios, and safest administration methods [17].	1b	B
	20. Clinically, botulinum toxin type A (BTX-A) is predominantly selected for application, although some scholars also suggest that BTX-A exhibits equivalent therapeutic efficacy to BTX-B [14,16,19]. The standard injection dose of BTX-A typically ranges from 55 to 250 IU, with 30 IU administered to each parotid gland and 20 IU to each submandibular gland [27]. For pediatric patients weighing less than 15 kg, the recommended dose is 15 IU per gland; for those weighing 15–25 kg, 20 IU per gland; and for those exceeding 25 kg, 25 IU per gland. A recommended injection interval of 6 to 12 months is advised [30].	1a	A
	21. When selecting the site for injection, the submandibular gland is the preferred choice, and the parotid gland may also be injected simultaneously [30]. Medical institutions with adequate resources recommend ultrasound-assisted localization. For ultrasound-guided localization, a high-frequency (5–10 MHz) probe should be used. The patient is typically positioned in the supine position during injection. For uncooperative children, sedation may be administered, or general anesthesia may be considered. The submandibular gland is divided into two quadrants (superior and inferior) for injection, while the parotid gland is divided into 4 quadrants (2 for superior and 2 for inferior). Care must be taken to avoid major blood vessels and nerves [12,30].	1a	A
	22. Caution should be exercised regarding the adverse effects of botulinum toxin, including local pain, altered salivary viscosity, and dry mouth. A minority of medical records have reported cases of cellulitis, dysphagia, and facial nerve palsy. If such symptoms occur, prompt notification to the physician is advised [2,12,30]. Adverse effects may be dose dependent. Botulinum toxin B can alleviate the frequency and severity of salivary secretion in children with cerebral palsy. Lower doses are ineffective, while higher doses do not enhance efficacy but may increase the incidence of additional adverse effects [21,27,31].	1b	B
Operative treatment	23. The surgical indications primarily include children with severe drooling who have failed conservative treatment, are over 6 years old, have undergone correction of triggering factors, and have shown no improvement after at least 6 months of exercise therapy, as well as those who may require lifelong pharmacotherapy, with insufficient benefit or discomfort from anticholinergic drugs and botulinum toxin A injections [12].	1a	B
	24. Surgical interventions regulate salivary secretion by reducing or eliminating neural stimulation of salivary glands, altering saliva flow patterns, employing ligations to block salivary flow and induce glandular atrophy, or directly excising salivary glands to terminate secretion. These procedures can be performed unilaterally or bilaterally and require general anesthesia. Common techniques include submandibular gland repositioning, submandibular gland ligation, submandibular gland excision, sublingual gland excision, parotid duct diversion, parotid duct ligation, and parasympathetic nerve sectioning. Combined surgical approaches demonstrate favorable outcomes, with comprehensive treatment regimens frequently adopted in clinical practice, particularly bilateral submandibular duct ligation [2,14,15].	1c	A

Table 6 (Continued)

Classification of evidence	Content of evidence	Evidence grade	Evidence recommendation strength
Radiotherapy	25. Radiotherapy can be used to control drooling, but its application in children is not recommended due to risks such as xerostomia, loss of taste, mucositis, radiation-induced caries, and radiation damage [30].	1b	B
Dynamic follow-up	26. Dynamic follow-up is recommended and scheduled after all pharmacological and/or surgical treatments, including short-term (8 weeks) and long-term (32 weeks) follow-ups, to evaluate the efficacy of interventions, adverse reactions, subjective feelings and satisfaction of the child or family members, as well as to assess new or ongoing treatment and care needs [2,25]. Treatment should be adjusted promptly based on the evaluation results.	1a	B
	27. For children receiving cholinergic medication, conduct a telephone assessment every 3 months to ensure treatment appropriateness [25].	1b	B
	28. To evaluate the long-term effects of interventions, a follow-up period of at least 18 months is recommended [2].	1b	A

4. Discussion

4.1. Multidisciplinary team collaboration is the key to managing drooling

Evidence 1 demonstrates that the treatment and management of drooling in children with cerebral palsy requires multidisciplinary collaboration and emphasizes the importance of establishing a multidisciplinary team. The group of children with cerebral palsy who drool is complex and diverse, and hides a series of neuromuscular dysfunction problems, such as oral motor dysfunction, primary neurological dysfunction, epilepsy and aspiration risk. It is difficult for a single specialty to balance various factors in clinical decision-making. However, the establishment and collaboration of a multidisciplinary team can largely complement the blind spots of treatment and management in various disciplines, so as to achieve the best possible comprehensiveness. This study emphasizes the advantages of the systematic and collaborative nature of multidisciplinary cooperation. The individualized treatment plan developed from multiple perspectives, including the patient's condition, psychological and social factors, can achieve the greatest therapeutic effect in complex clinical situations. This study also suggests that, in addition to medical staff, professionals with experience in caring for children with disabilities and special needs should be included in the drooling treatment management team [25,32]. Based on more than 20 years of work experience, the Dutch Orriëns LB et al. team proposed a structured algorithm model for MDT clinical decision-making, including step-by-step decision-making, baseline comprehensive assessment and family participation in shared decision-making [25]. Its core principle is not to pursue a single "stop drooling", but to pursue an individualized plan with the core goal of improving the quality of life of children and their families, preventing the occurrence of complications and promoting the social integration of children. At the same time, the NICE guidelines also emphasize that all decisions need to take into account the needs of the child and caregiver, as well as family preferences and values [12]. Therefore, it is recommended that multidisciplinary collaboration be further developed from a concept into an important decision support tool for the treatment and management of drooling in children with cerebral palsy. It could also be considered to incorporate it into a standardized clinical pathway centered on the child and family, based on structured assessment and decision algorithms, in order to bridge the gap between best evidence and family practice and promote more comprehensive, systematic and effective treatment and management of

drooling.

4.2. Comprehensive and stepwise evaluation of sialorrhea symptoms is the prerequisite for improving sialorrhea symptoms

Evidence 2–6 summarizes the assessment strategy for drooling in children with cerebral palsy. A step-by-step and comprehensive pre-treatment assessment is a prerequisite for safe and precise treatment. The assessment can be conducted in the following steps. First, classification of children with cerebral palsy according to the European Cerebral Palsy Surveillance (SCPE) and the Gross Motor Function Classification System (GMFCS-E&R) [33,34]. Second, according to the international consensus statement, different types of drooling should be distinguished. For the posterior type that requires special treatment, accurate identification and proper handling are necessary. The evidence summarized in this study is all for anterior type drooling or combined type drooling [2]. Third, make a clear diagnosis based on age, symptoms, relevant guidelines and auxiliary methods, and determine whether it is physiological or pathological drooling; 4. Assess and record the child's developmental age and dental age, evaluate the child's overall condition, and use appropriate and effective assessment tools to assess the severity of drooling. This study emphasizes that in addition to assessing the physical problems caused by drooling, it is also necessary to conduct a comprehensive assessment of the psychological state, social impairment, and quality of life of the child and their caregivers.

The international academic community has gradually shifted from relying solely on objective indicators to integrating caregiver self-report data, and is paying more and more attention to the subjective feedback of patients and their families [35]. Therefore, in addition to the above quantitative measurements, before formulating the best treatment plan, it is also necessary to consider the personal wishes and preferences of the child and their caregiver, combine the quantitative measurement indicators, the patient's self-reported outcome indicators and the caregiver's subjective opinions, and comprehensively consider them to further formulate treatment and management measures [18,27,30].

4.3. Adherence to therapeutic principles is a critical measure for effective management of drooling

Evidence 7–10 summarizes the treatment principles for drooling in children with cerebral palsy. Based on the literature retrieved so far, there are no clear guidelines or consensus on which intervention measures are the safest and most effective for children with different degrees of drooling. Therefore, when formulating clinical decision-making plans, multiple factors should be considered, including safety, efficacy, patient acceptance, patient and caregiver compliance with treatment measures, side effects, and quality of life [25]. Following the principle of "conservative treatment first, drug intervention second, and surgical treatment last", individualized treatment and management plans are developed and adjusted promptly based on monitoring and follow-up results. It is advocated to prioritize fewer invasive interventions, such as behavioral and physical therapy, followed by drug therapy [30]. Depending on the treatment effect, the dosage and intensity of treatment should be gradually increased as necessary, and finally, more invasive or side-effect-prone treatments such as botulinum toxin injection, surgical treatment, and radiotherapy should be considered.

Evidence 11–25 comprehensively summarizes various treatment modalities, including behavioral, physical, pharmacological, intradermal botulinum toxin injection, surgical, and radiation therapies, along with corresponding recommendations. Considering the complexity of the etiology and the individual differences in drooling, it is recommended that, based on the overall treatment principles, an individualized treatment plan combining multiple

treatment methods be considered. However, (e.g., Evidence 13 suggests integrating elastic therapy patches with oral training techniques, and Evidence 14 recommends combining orthodontic appliances with oral motor therapy), or combining physical therapy with pharmacotherapy, or pharmacotherapy with surgical intervention [2,18]. These approaches not only enhance treatment efficacy and reduce medication dosage but also facilitate the selection of minimally invasive surgical methods and avoid overtreatment. Intra-glandular injection of botulinum toxin is an important intervention method in the clinical treatment of drooling in cerebral palsy. It can directly act on the gland and inhibit glandular activity, thereby reducing saliva secretion [30]. Among many treatment methods, intraglandular injection of botulinum toxin has a clear therapeutic effect, long duration, relatively few complications, and wide applicability to a wide age range [23]. However, due to limited data in the literature, it is unclear whether this treatment is applicable to all children with cerebral palsy or neurodevelopmental disorders, and the operating procedures and dosages reported by various treatment centers lack uniformity and standardization [17]. Surgical procedures are invasive treatments. If other treatments cannot achieve the desired effect, surgical procedures may be considered as appropriate after strict evaluation of the indications, clarification of the expected effect of the surgery, and respect for the wishes of the child and their caregivers [25]. While this study summarized numerous treatment methods, it failed to provide a one-to-one correspondence between treatment methods and the severity of drooling. Therefore, it is difficult for physicians to standardize and homogenize their treatment decisions. It is hoped that future clinical studies will address this deficiency.

4.4. Dynamic follow-up after treatment is a critical safeguard to ensure therapeutic efficacy

To continuously assess the effectiveness of treatment measures, monitor adverse reactions, evaluate the improvement in the quality of life of children and their families, and assess long-term efficacy, Evidence 26–28 summarizes the best evidence for dynamic follow-up after treatment. As Orriëns LB et al. pointed out, controlling drooling requires “stepwise decision-making” [25]. Given that children with cerebral palsy are in a period of rapid development and considering the long-term nature of drooling treatment and the varying durations of effectiveness and risk profiles of different interventions, continuous dynamic follow-up after treatment is crucial to ensuring treatment effectiveness [21,36]. Physicians need to adjust the treatment plan in a timely and dynamic manner based on the follow-up results. Ultimately, by combining objective indicators such as the effectiveness of treatment with subjective indicators such as the needs of the child and caregivers through regular, structured reassessments, the treatment plan can be dynamically optimized, thereby promoting the goal of improving quality of life. Therefore, it is recommended to implement long-term dynamic management for children with cerebral palsy, and to carry out a cyclical process of “comprehensive assessment–professional intervention–reassessment–adjustment” by a multidisciplinary team.

5. Summary

This study summarizes the best evidence for the treatment and management of drooling in children with cerebral palsy, including 10 aspects of the entire process of drooling treatment and management, such as the establishment of a multidisciplinary team, comprehensive step-by-step assessment, treatment principles, treatment methods, and monitoring and follow-up. It can provide some reference for clinical practice. Medical staff can use appropriate evidence to carry out treatment based on the clinical situation, the patient’s condition, and the wishes of the child and his/her family, thereby improving the efficacy of treatment, reducing complications, and improving the quality

of life of children with cerebral palsy and their families.

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