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5-Year Experience in Saliva Control Clinic in a Tertiary Center: Outcome of Drooling in Children

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ABSTRACT

Background: Drooling beyond age 4 is pathological, requiring investigation and intervention. The lack of a standardized approach to treating children with drooling poses a challenge in managing these patients.

Methods: A retrospective review of all children under 18 attending the saliva control clinic between 2018 and December 2023 was conducted.

Results: A total of 117 children were included. The mean age of the children was 10 years (SD = 4.74), with a male predominance of 68.4% noted. The most common comorbidity was cerebral palsy (CP), 35.9%. Twenty-nine (24.8%) of the included children were otherwise healthy. Children with CP were more likely to receive Botulinum toxin A injection ($P < .001$) and scopolamine patch ($P < .001$). Improvement was reported in 80.3%, with complications documented in 9% of children.

Conclusion: The included patients reported satisfactory results (89.7%). The importance of multidisciplinary team involvement was highlighted to ensure holistic management.

Keywords: Children, drooling, pharmacological, saliva, surgical outcome

Introduction

Drooling, or unintentional loss of saliva, results from an impaired oral phase of swallowing and is related to the lack of coordinated control of the tongue and oral musculature.[1] Saliva control indicates the maturation of oral sensory-motor function and coordination of swallowing.[2] Drooling, when visible on the exterior of the child's lower lip and chin, is known as anterior drooling, while spillage beyond the oropharynx is classified as posterior drooling.[1] Drooling is regarded as normal up until the age of 2 years, although some authors accept drooling in children until the age of 4.[3,4]

Drooling is a silent condition that has a detrimental impact on the quality of life of both the child and the parents or caretaker.[5] The constant dripping or accumulation of saliva can cause skin irritation, dental caries, impaired swallowing and speech,[2] oral infections,[2] aspiration and recurrent chest infection,[2] and hospital admissions. Children with persistent drooling tend to have low self-esteem and are prone to being bullied at school, resulting in anxiety and embarrassment,[6] leading to physical and emotional isolation.[7] Moreover, the frequent need to change clothes or use bibs may be a hassle for the child and the parent.[7]

A definite algorithm or approach to a drooling child remains elusive to date. Moreover, specialized clinics for managing drooling children remain scarce. Drooling in children should be managed by a team of experienced professionals who manage children with special needs. The saliva control clinic in the center is the only multidisciplinary clinic in the region that is explicitly dedicated to children and adolescents. This article aims to review the management and outcome of the saliva control clinic in the centre. It is hoped that this article serves as a foundation for ongoing research and development, reinforcing the commitment to enhancing the quality of children facing saliva control challenges.

Material and Methods

A retrospective medical chart review of all children who attended the saliva control clinic, a 3-monthly multidisciplinary

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clinic in a single center from January 2018 to December 2023, was reviewed. The authors adhered to the STrengthening the Reporting of Observational studies in Epidemiology (STROBE) guidelines while undertaking the study. Each patient included in this study has at least 1 follow-up. The Auckland Health Research Ethics Committee has approved this project (ID: INC0012613).

The saliva control clinic at the center is a multidisciplinary clinic that encompasses pediatric otorhinolaryngologists, speech and language therapists, and pediatric dentists. All children attending the clinic were referred from various pediatric specialties, some of whom had already started some form of treatment.

Each child attending the clinic undergoes a rigorous initial assessment, with parents and caretakers actively participating to ensure optimal treatment is delivered. An individualized, step-wise approach is advocated, beginning with the least invasive option and subsequently moving to surgical treatment options if necessary (Figure 1. Summary of treatment approach in a drooling child).

Follow-up Duration

All children were followed from their initial visit until either the completion of the prescribed management plan or the achievement of clinical stability. The duration of follow-up ranged from 12 to 56 months (median = 34 months). Complications and outcomes were documented at every visit.

Definition of Improvement

"Improvement" was defined as either (i) a ≥1-point reduction in drooling severity or frequency based on caregiver report using the Drooling Severity and Frequency Scale or (ii) caregiver-reported functional improvement, including reduced bib use, fewer clothing changes, decreased perioral skin breakdown, improved oral continence, or safer feeding.

Treatment decisions were made using a multidisciplinary consensus considering drooling severity, aspiration or feeding concerns, skin integrity, the child's cognitive and physical ability to participate in therapy, age, previous response to treatment, parental preference, and contraindications to pharmacological therapy. Children typically progressed from conservative to pharmacological to interventional options depending on treatment response.

Non-pharmacological therapies (including oral motor therapy, positioning therapy, behavioral therapy, and Castillo-Morales therapy) were typically delivered over 6-12 months, depending on the child's participation and response. Pharmacological treatments were prescribed based on clinician judgment, with dosing and duration individualized according to patient response and tolerance. Interventional treatments followed established timelines—botulinum toxin injection was reviewed at 3-6 months post-treatment, while surgical procedures (including duct ligation, submandibulectomy, and adenotonsillectomy) were reviewed at 1 month, 3 months, and again at 6-12 months.

Outcome Measures

The primary outcome was improvements as defined earlier. Secondary outcomes include treatment-related complications.

Statistical Analysis

Data collected was analyzed using SPSS, version 26.0. Descriptive statistics were used to describe the demographic characteristics of the participants. Continuous variables are presented as mean ± standard deviation (SD) as they were found to be normally distributed, while categorical variables are presented as frequency and percentage.

Pearson chi-squared test and Fisher exact tests were used to test the association between:

- Comorbid and treatment type
- Treatment type with the presence of complication
- Presence of complications with the patient's outcome

Post hoc pair-wise comparison was performed following the significance of the association testing with Bonferroni correction to identify the subgroups with observed significant association. All the tests were 2-sided, and statistical significance was denoted by $P < .01$.

Main Points

- Drooling beyond 4 years requires attention, especially in an otherwise healthy child.
- A multidisciplinary team collaboration between pediatric otorhinolaryngologists, speech and language therapists, and pediatric dentists enables the thorough management of a drooling child.
- A step-wise approach is required when managing a child with drooling using the least invasive approach, such as behavioral and oral-motor therapy.
- Children with complex medical backgrounds, such as cerebral palsy, may require multimodal therapy, such as positional and pharmacological therapy and, if it persists, surgical treatment.
- The establishment of a saliva control clinic for children promises a successful outcome.

Results

A total of 117 participants were recruited for the study, with a mean age of 10 years (SD = 4.74). The majority of them were male (68.4%). As for the comorbidities, 42 had cerebral palsy (CP), 29 were otherwise healthy (24.8%), 20 had syndrome or microdeletion, 23 had neurological deficits, and 3 had other comorbidities (Table 1).

A total of 60.7% (n = 71) of children underwent multiple treatments. The most favored mode of therapy in the center is Hyoscine patch (scopolamine) (n = 51), followed by intraglandular Botulinum toxin A (Botox) injection (n = 45), oromotor therapy (n = 32), adenotonsillectomy (n = 22), Castillo-Morales prosthesis in 18 children, behavioral therapy in 15 children, submandibulectomy in 13 children, swallow prompt application in 13 children, ligation of salivary duct in 11 children, and other forms of anticholinergic agents in 5 children. Non-pharmacological therapy was prescribed in 78 children, pharmacological treatment in 101 children, and 46 children

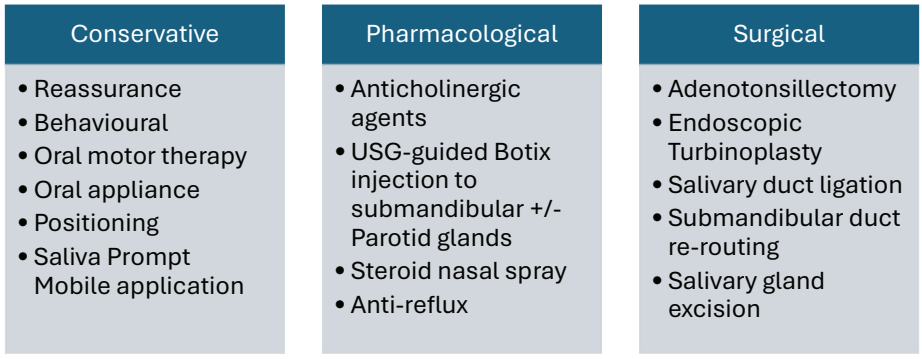

Figure 1. Summary of treatment approaches.

Table 1. Demographic Characteristics of the Participants

Characteristics		Output
Age in years, mean ± SD		10.17 ± 4.74
Gender, n (%)	Male	80 (68.4)
	Female	37 (31.6)
Comorbid, n (%)	Healthy	29 (24.8)
	CP	42 (35.9)
	Syndrome/ microdeletion	20 (17.1)
	Neurological deficit	23 (19.7)
	Other	3 (2.6)

CP, cerebral palsy.

underwent surgical intervention. No significant association was found between the presence of underlying comorbidities and the type of intervention ($P > .05$). Table 2 summarizes the association between comorbid conditions and the type of treatment.

In the series, 29 children were defined as "healthy droolers" as they were otherwise healthy and had no underlying comorbidities. The mean age of these healthy droolers was 7.7 ± 4.1 years. The most common mode of treatment was nonpharmacological. Adenotonsillectomy was the only surgical intervention among these groups (n = 10). Twelve of these children underwent multimodal treatment, whereby nonpharmacological treatment was the most favored (oromotor therapy (n = 11), oral appliance (n = 7), behavioral (n = 7), and swallow prompt application (n = 5).

Meanwhile, improvement following treatment was reported in 94 children, with complete resolution in 11 children. Yet, persistent drooling was found in 12 children. Among the healthy droolers, improvement was reported in all children, although complete resolution was observed in 11 of the 29 children. No significant association was observed between the presence of complications and patients' outcomes ($P = .150$).

Complications from treatment were observed in 9% of children (n = 12). Eight children were reported to have skin irritation from the Hyoscine patch, whereas 3 children were reported to have temporary dysphagia and swelling of the gland (n = 1) following botulinum toxin injection to the submandibular gland.

A higher proportion of patients with CP were observed to receive Botox ($P < .001$) and Hyoscine patch ($P < .001$). On the other hand, healthy patients were observed to be less likely to receive Botox ($P < .001$) and the Hyoscine patch ($P < .001$).

The association between the type of treatment and complications is explored in Table 3, where it is observed that oral glycopyrrolate is associated with a higher complication rate compared to patients who did not receive the treatment ($P < .001$). Complications were observed in 11 children.

No significant association was found between the presence of comorbidities and treatment type in the presence of complications ($P > .05$, Table 4). A significant association was observed between the presence of comorbidities and patient outcomes,

Table 2. Association Between the Presence of Comorbidities with Treatment Type

	Treatment			
Variables	Non-surgical	Surgical	Both	*P*
Comorbid				.705
Healthy	19 (25.0)	4 (40.0)	6 (19.4)	
CP	26 (34.2)	3 (30.0)	13 (41.9)	
Syndrome/microdeletion	14 (18.4)	1 (10.0)	5 (16.1)	
Neurological deficit	16 (21.1)	1 (10.0)	6 (19.4)	
Other	1 (1.3)	1 (10.0)	1 (3.2)	

Fisher exact test.
CP, cerebral palsy.

Table 3. Association Between Treatment Type and Complication

Treatment Modality	No Complication n (%)	Complication n (%)	*P*
Adenotonsillectomy	84 (79.2)	11 (100.0)	.122
Botox	66 (62.3)	6 (54.5)	.747
Ligation	98 (92.5)	8 (72.7)	.068
Submandibulectomy	95 (89.6)	9 (81.8)	.352
Oromotor therapy/positioning	77 (72.6)	8 (72.7)	>.950
Hyoscine patch	60 (56.6)	6 (54.5)	>.950
Oral glycopyrrolate/others	106 (100.0)	6 (54.5)	**<.001**
Castillo morales therapy	89 (84.0)	10 (90.9)	>.950
Behavioral therapy	92 (86.8)	10 (90.9)	>.950
Swallow App	93 (87.7)	11 (100.0)	.609

whereby patients without comorbidities were more likely to experience complete resolution of symptoms than those with comorbidities ($P < .001$). Although a significant association was observed between treatment type and patients' outcomes ($P = .034$), post hoc pair-wise comparisons showed no significant pairs after Bonferroni correction (Table 5: Post-hoc pair-wise comparison).

Discussion

The International Pediatric Otorhinolaryngology Group (IPOG) Consensus paper advocates for the role of a multidisciplinary team (MDT) due to the complex and multifaceted nature of drooling in children, ensuring an individualized approach.[1]Nonetheless, only 25% of the included experts in the IPOG consensus had MDT clinics in their center, suggesting the need for more Saliva Control MDT services across the globe. Among the prominent reported challenges and constraints hindering the MDT services were a lack of time, funding, administrative challenges, and limited resources.[1]Yet, it is worth noting that awareness among parents/caretakers and other physicians on the importance of management of saliva control in children is crucial and needs global attention.

Assessment of drooling children must incorporate a thorough history-taking, followed by a physical examination. History should include the age of onset, duration, triggering and relieving factors or maneuvers, medication history, developmental history, and perinatal history. The severity of drooling needs to be assessed and should include the number of bibs or tops changed daily, as well as the presence of complications such as skin excoriation. Questions directed to posterior drooling, such as coughing and choking with or without feeding, recurrent chest infections, as well as the need for respiratory support or regular suctioning, are crucial. Developmental and motor milestones are essential, as drooling could be an early sign of developmental delay in an otherwise healthy child. Questionnaires can aid in taking history, understanding the severity of drooling, and tracking treatment progress.

In the saliva control clinic, thorough and meticulous examinations are conducted to identify the potential cause of drooling. It is advocated that the examination of a drooling

Table 4. Association Between Treatment Type with Patients' Outcome

	Outcome			
	Persists	Improve	Resolve	*P*
Comorbid				<.001
Healthy	0 (0.0)	18 (19.1)	11 (100.0)	
CP	6 (50.0)	36 (38.3)	0 (0.0)	
Syndrome/microdeletion	3 (33.3)	16 (17.0)	0 (0.0)	
Neurological deficit	2(16.7)	21 (22.3)	0 (0.0)	
Other	0 (0.0)	3 (3.2)	0 (0.0)	
Treatment type				.034
Non-surgical	8 (66.7)	64 (68.1)	4 (36.4)	
Surgical	0 (0.0)	6 (6.4)	4 (36.4)	
Both	4 (33.3)	24 (25.5)	3 (27.3)	

Fisher exact test
CP, cerebral palsy.

Table 5. Post Hoc Pairwise Comparison

	Outcome					
	Persists	*P*	Improve	*P*	Resolve	*P*
Comorbid						
Healthy	0 (0.0)	.540[b]	18 (19.1)	.060[a]	11 (100.0)	<.001[b]
CP	6 (50.0)	>.950[b]	36 (38.3)	>.950[b]	0 (0.0)	.105[b]
Syndrome/microdeletion	3 (33.3)	>.950[b]	16 (17.0)	>.950[b]	0 (0.0)	>.950[b]
Neurological deficit	2(16.7)	>.950[b]	21 (22.3)	>.950[b]	0 (0.0)	>.950[b]
Other	0 (0.0)	>.950[b]	3 (3.2)	>.950[b]	0 (0.0)	>.950[b]
Treatment type						
Non-surgical	8 (66.7)	>.950[b]	64 (68.1)	.945[b]	4 (36.4)	.063[b]
Surgical	0 (0.0)	>.950[b]	6 (6.4)	>.950[b]	4 (36.4)	.441[b]
Both	4 (33.3)	>.950[b]	24 (25.5)	>.950[b]	3 (27.3)	>.950[b]

CP, cerebral palsy.
[a]Pearson chi-squared test.
[b]Fisher exact test.

child should incorporate oro-facial, neurological, and musculoskeletal examinations. The presence of skin maceration or excoriation, evidence of saliva spillage, malocclusion, facial paralysis or apraxia, muscle wasting, and head and neck posture should be evaluated. The intraoral examination is crucial for detecting the presence of dental caries and assessing general dental health, as well as ankyloglossia, tonsillar hypertrophy, oral ulcers, macroglossia, occlusal abnormalities, or any other lesions. A neurological examination can be carried out if feasible. Similarly, a bedside flexible nasoendoscopy can provide information on the presence of any structural obstructions, such as inferior turbinate or adenoid hypertrophy, a deviated nasal septum, as well as signs of laryngeal aspiration, penetration, or pooling of saliva in the hypopharynx. The IPOG Consensus also emphasizes the importance of eye examination prior to medical treatments involving anticholinergics.[1]

In the clinic, a stepwise approach is followed from conservative to pharmacological to surgical intervention, as previously described.[8]Non-pharmacological interventions include behavioral strategies, oral awareness and oral stimulation training, orthodontic treatment, saliva prompt application, such as the Saliva Prompt App, and oral appliances such as the Castillo-Moreles prosthesis. Experts from the IPOG Consensus documents chose observation in children with: mild to moderate symptoms, healthy children below 4 years of age with no lung issues, low impact of drooling on overall quality of life, and when parents were not concerned.[1]

The non-pharmacological approach is more of a rehabilitative approach, which is non-invasive and safe with no complications or side effects. Oral motor therapy, for example, is believed to improve lip and tongue mobility, as well as lip closure, thereby promoting saliva swallowing.[9,10] Moreover, oral sensitivity and awareness have been reported to improve following oral motor therapy. The behavioral approach includes positive and negative reinforcement, cueing techniques, and self-management procedures. Recommendations for non-pharmacological therapy, based on IPOG experts, include oro-motor and sensory awareness therapy (94%), behavior therapy (60%), and positioning (60%).

Pharmacological treatment includes medications to reduce saliva production, such as anticholinergic agents that block the parasympathetic muscarinic innervation of the major salivary glands. Transdermal hyoscine patches are the first-line pharmacological treatment in the center, due to their convenient mode of administration, in contrast to 3 times daily oral glycopyrrolate. 43.6% of children in the series were started on a hyoscine patch.

However, the hyoscine patch is not without side effects, with skin reactions reported in most research articles.[1,8] In the series, 15.7% of children who started on the hyoscine patch developed skin irritation or reaction. Additionally, several other pharmacological agents can be used, including benzhexol, atropine drops, and oral glycopyrrolate. Notable side effects of these muscarinic agents include sticky secretions, blurred vision, hyperactivity, and urinary retention.[11]The most common pharmacological agents by IPOG experts include botulinum toxin injections, glycopyrrolate, and scopolamine patch (hyoscine).[1]

Botulinum toxin A administered to the submandibular and/or parotid glands has shown promising results, albeit only temporarily. It was first introduced in 1997 by Bushara et al, who injected the salivary glands of adult patients with amyotrophic lateral sclerosis.[12] Botulinum toxin was first administered in children with CP, with a successful reduction in saliva, as demonstrated by Jongerius et al.[13] Botulinum toxin A works by inhibiting the release of pre-synaptic acetylcholine at the neuroglandular junction, causing parasympathetic denervation that subsequently reduces salivary secretion (IPOG).[1] Botulinum toxin can be injected into the salivary gland by manual palpation using the anatomical landmark, ultrasonography guidance, or electromyography guidance.[10] Many authors have lauded the ultrasound-guided technique for its increased efficacy and safety, which in turn reduces the complication rate.[14-17]

Side effects of botulinum toxin include dry mouth, thickened secretion or saliva, swelling of the salivary gland,[18] and temporary dysphagia.[19] Dysphagia has been reported to be secondary to the diffusion of the toxin into the surrounding muscles, leading to dysphagia and transient weakness of muscle closure.[20]

The main drawback of botulinum toxin injection is that it is only temporary, with reported effectiveness between 8 and 16 weeks,[21,22] requiring repeated injections every 3 and 6 months. The longer duration of effectiveness has been attributed to the use of ultrasound guidance.[19] Forty-five children in this series underwent botulinum toxin injection, either bilateral or 4-gland injection. Complications in the series include temporary dysphagia (n = 3), swelling of the salivary glands, and thick secretion (n = 1). It is postulated that the temporary dysphagia following the botulinum toxin injection in the series was due to the administration of a higher dose than the normal dose. A subsequent guideline was established to standardize Botox dosing with no further cases of dysphagia noted.

In the center, botulinum toxin is administered via ultrasound guidance by the interventional radiologist under general anesthesia, followed by close monitoring and observation postoperatively. Although the efficacy of Botulinum toxin was not determined, the low complication rate is likely due to the use of ultrasound guidance.

Other pharmacological agents reported include anti-reflux medications, nasal steroids, and nasal decongestants. If nasal obstruction is suspected, steroid nasal sprays can be trialed for 6 weeks before a decision is made regarding adenoidectomy or inferior turbinate cautery.

Surgical options were recommended by 95% of IPOG experts to children above 4 years of age with severe anterior drooling that failed conservative management and pharmacotherapy.[1]Surgical interventions were performed in 39% of the included children. In children with drooling and significant adenotonsillar hypertrophy, the child is booked for adenotonsillectomy at the first visit, especially if it is associated with sleep-disordered breathing or recurrent tonsillitis. A proportion of drooling children who were found to improve with botulinum toxin injections were subsequently treated with either bilateral excision of submandibular glands or salivary duct ligation. 9% of the included children underwent submandibular and/or parotid duct ligation. In the center, the approach is to recommend bilateral submandibular duct ligation as initial surgical management, and only if persistent symptoms persist are the parotid ducts ligated. One patient developed a ranula following submandibular duct ligation that was subsequently treated with sublingual gland excision. Aside from mild, temporary swelling, no other complications were encountered.

Submandibular gland excision was performed in 13/117 children either unilaterally or bilaterally, depending on the severity of the drooling and the child's comorbidities. One case of marginal mandibular nerve palsy was reported following submandibular gland excision. Two out of 11 children treated with salivary duct ligation and submandibular gland excision had persistent symptoms, which could be attributed to the severity of the underlying neurological condition.

In otherwise developmentally normal children, simple assurance has been previously advised.[8] Having said that, drooling in a healthy child could indicate that there may be oral musculature motor-sensory incoordination and an early warning sign of developmental delay. In the series, it was found that 29 of the included children were healthy droolers. Hulst et al reported that 3%-15% of healthy preschoolers were reported to be droolers beyond 4 years of age, of which 3% of the included children were found to be pathological droolers.[23] Akin to that, in the series, although improvement was reported in all children following treatment, complete resolution was demonstrated in 11/29 children.

The assessment of drooling children should ideally take place within a multidisciplinary clinic. A holistic evaluation of the drooling child should be undertaken, and interventions should be offered to selected patients. Interventions for drooling should be stepwise, with the least invasive treatments considered first, and realistic expectations should be given to parents. Surgical treatment for drooling may be considered in patients who have already received less invasive interventions and continue to experience symptoms. These procedures need to be carefully considered in the context of the patient's comorbidities and quality of life.

Limitation

The series is not without limitations. Only a very small number of patients could be included, as only children listed in the salivary control clinic were included. Children seen and managed in the outpatient clinic were not included. The long-term outcome of the treatments administered is yet to be explored.

Conclusion

In the series, satisfactory results were reported among the children managed in the saliva control clinic (89.7%). The importance of multidisciplinary team involvement is highlighted to ensure holistic management. The importance of identifying drooling in otherwise healthy children and healthy droolers is also advocated, which was successfully managed in the series.

Data Availability Statement: The data that support the findings of this study are available on request from the corresponding author.

Artificial Intelligence Usage Statement: The authors declared that no Artificial Intelligence Tool was used in the preparation of the manuscript.

Ethics Committee Approval: Ethics committee approval was received from the Ethics Committee of Auckland Health Research Ethics Committee (Approval no: INC0012613, Date: 02.03.2024).

Informed Consent: Verbal informed consent was obtained from the patients who agreed to take part in the study.

Peer-review: Externally peer-reviewed.

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