International Journal of Innovative Technologies in Social Science

e-ISSN: 2544-9435

Operating Publisher
SciFormat Publishing Inc.
ISNI: 0000 0005 1449 8214

2734 17 Avenue SW,
Calgary, Alberta, T3E0A7,
Canada
+15878858911
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ARTICLE TITLE	ULTRASOUND-GUIDED SALIVARY GLAND BOTULINUM TOXIN FOR CHRONIC SIALORRHEA IN OTOLARYNGOLOGY: PROCEDURAL TECHNOLOGY, SERVICE DELIVERY, AND PUBLIC HEALTH OUTCOMES
DOI	https://doi.org/10.31435/ijitss.1(49).2026.6057
RECEIVED	19 January 2026
ACCEPTED	27 March 2026
PUBLISHED	30 March 2026
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ULTRASOUND-GUIDED SALIVARY GLAND BOTULINUM TOXIN FOR CHRONIC SIALORRHEA IN OTOLARYNGOLOGY: PROCEDURAL TECHNOLOGY, SERVICE DELIVERY, AND PUBLIC HEALTH OUTCOMES

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ABSTRACT

Chronic sialorrhea has consequences that extend far beyond visible drooling. In otolaryngology practice it can affect airway protection, skin integrity, communication, feeding routines, social participation, school or work functioning, and unpaid caregiver time. This review synthesizes PubMed-indexed evidence on salivary gland botulinum toxin with particular attention to how imaging support, care setting, and service organization shape clinical and public-health outcomes. PubMed was used as the core database for a structured narrative search completed on March 12, 2026, and evidence was synthesized thematically, prioritizing randomized trials, systematic reviews, consensus documents, and larger cohort studies. Across adult and pediatric populations, botulinum toxin consistently reduces drooling severity in appropriately selected patients, while ultrasound guidance improves localization confidence and supports more reproducible, teachable protocols. The major unresolved questions concern optimal gland combinations, formulation-specific dose strategies, longer-term respiratory outcomes, comparative costs across settings, and equitable access for medically underserved populations. Current evidence supports botulinum toxin as a minimally invasive component of stepwise drooling management when paired with structured swallowing assessment, caregiver-centered outcomes, and implementation models that reduce avoidable anesthesia exposure and travel burden.

KEYWORDS

Sialorrhea, Botulinum Toxin, Ultrasound Guidance, Otolaryngology, Health Technology, Public Health

CITATION

Daria Danielczyk, Michał Babicz, Kamil Chudzicki, Wiktor Czyżewski, Katarzyna Rosa, Agata Słoma, Anna Szot, Dominik Szydełko, Martyna Szymczyk, Paweł Żurek. (2026) Ultrasound-Guided Salivary Gland Botulinum Toxin for Chronic Sialorrhea in Otolaryngology: Procedural Technology, Service Delivery, and Public Health Outcomes. *International Journal of Innovative Technologies in Social Science*. 1(49). doi: 10.31435/ijitss.1(49).2026.6057

1. Introduction

Sialorrhea is best understood as a saliva control disorder rather than a simple problem of salivary overproduction. In many children and adults the central mechanism is impaired oral motor control, reduced swallowing frequency, diminished lip seal, or inadequate clearance of saliva that is produced at near-normal physiologic rates. This distinction has practical implications. It helps explain why drooling is common in cerebral palsy, intellectual disability, Parkinson disease, atypical parkinsonism, stroke, traumatic brain injury, and other neurologic conditions, yet still presents with highly variable severity and consequences. It also explains why a local treatment directed at salivary glands can be useful when conservative measures are insufficient, even though the primary disorder often lies in neuromotor control rather than true hypersalivation (Daniel et al., 2023; Hockstein et al., 2004; Jost et al., 2023).

The burden of chronic drooling extends well beyond wet clothing. Patients may experience perioral irritation, malodor, reduced intelligibility of speech, social embarrassment, and disrupted feeding routines. Families and formal caregivers frequently absorb the hidden labor of constant wiping, bib changes, suctioning, laundering, skin care, and vigilance for choking or aspiration. In medically fragile children and adults, posterior drooling and secretion pooling can coexist with recurrent chest infections, repeated antibiotic exposure, and complex decisions about nutrition and airway protection. For that reason, sialorrhea should be treated not only as an individual symptom but as a functional and public-health problem tied to disability, quality of life, and healthcare utilization (Fan et al., 2022; Faria et al., 2015; Hockstein et al., 2004).

This topic sits naturally within otolaryngology. Otolaryngologists assess the upper aerodigestive tract, swallowing mechanism, airway anatomy, secretion burden, and aspiration risk, while also being asked to compare nonsurgical, procedural, and surgical options. In many centers ENT clinicians help decide whether drooling is predominantly anterior or posterior, whether flexible endoscopic or fluoroscopic swallowing assessment is needed before intervention, and whether minimally invasive gland injection or more definitive

surgery is the best next step. The specialty therefore links symptom control with airway protection and dysphagia management in a way that cannot be reduced to simple drug prescribing.

The relevance to IJITSS lies in the fact that salivary gland botulinum toxin is not only a drug intervention but also a health technology problem. Ultrasound-guided injection raises questions about procedural standardization, image-guided care, clinic versus operating-room delivery, training, documentation, access, and equity. It also creates a bridge between clinical outcomes and health-system outcomes such as caregiver burden, school and social participation, anesthesia exposure, waiting times, and cost. In other words, the intervention becomes especially interesting when evaluated as a combination of imaging technology, multidisciplinary service design, and measurable public-health impact.

Accordingly, this review examines how the contemporary PubMed literature informs patient selection, injection planning, imaging support, outcome measurement, and system-level delivery of salivary gland botulinum toxin in otolaryngology practice.

2. Methodology

This article was designed as a narrative evidence review organized around predefined clinical and implementation themes rather than as a formal systematic review. That approach was chosen because the literature combines randomized trials, consensus statements, localization studies, pediatric cohorts, and service-delivery reports that are difficult to pool statistically but highly relevant to real-world decision-making.

PubMed served as the core source because the landmark efficacy trials, consensus recommendations, and many of the strongest comparative studies in this field are indexed there. The search combined terms for sialorrhea or drooling, botulinum toxin formulations, parotid and submandibular glands, ultrasound or image guidance, and otolaryngology or neurologic care settings. Reference lists of key reviews and trials were also screened to avoid missing older anchor studies.

Study selection followed topic relevance and methodological strength rather than a rigid score-based rule. Priority was given to systematic reviews, meta-analyses, randomized or controlled studies, consensus documents, and larger observational cohorts. The synthesis was organized around seven practical domains: candidacy for treatment, gland choice, the role of ultrasound, dosing and retreatment, outcome measurement, safety, and public-health or implementation consequences.

From each included source, the review recorded the clinical population, age group, underlying diagnosis, drooling phenotype when available, target glands, guidance technique, toxin product and dosing approach, care setting, efficacy endpoints, adverse effects, and any caregiver, respiratory, utilization, or cost outcomes.

During drafting, the goal was to integrate findings across studies rather than mirror the wording or structure of any single source. Factual statements were tied to cited literature whenever possible, while interpretive comments were limited to conclusions that could be reasonably supported by the evidence summarized here.

Table 1. Structured PubMed-led search logic and thematic focus

Concept	Illustrative terms	Purpose in this review
Condition	“sialorrhea” OR drooling OR hypersalivation	To identify the core clinical and epidemiologic literature.
Intervention	“botulinum toxin” OR incobotulinumtoxinA OR onabotulinumtoxinA OR rimabotulinumtoxinB	To capture formulation-specific efficacy and safety evidence.
Targets	“salivary gland” OR parotid OR submandibular	To examine gland selection and targeting strategies.
Technology	ultrasound OR image-guided OR landmark	To evaluate procedural localization and implementation of imaging.
Context	otolaryngology OR ENT OR pediatric OR Parkinson disease OR aspiration OR cost	To connect clinical evidence with service delivery and public-health outcomes.

3. Results and interpretive synthesis

3.1. Evidence landscape and heterogeneity

The current evidence base is broader than many clinicians assume, yet methodologically uneven. It now includes adult randomized phase III data, pediatric phase III data, systematic reviews, meta-analyses, consensus statements, long-term extension data, localization studies, and retrospective implementation cohorts. The field has therefore moved well beyond anecdotal practice, but cross-study comparison remains difficult because populations, dosing schemes, gland targets, follow-up intervals, and outcome measures vary substantially (Berweck et al., 2021; Jost et al., 2019; Jost et al., 2020; Yu et al., 2022).

This heterogeneity is not just a statistical nuisance. It reflects the fact that chronic drooling is a syndrome shared by very different neurologic populations with different respiratory risks, communication priorities, caregiver environments, and service constraints. From a technology-assessment perspective, salivary gland botulinum toxin should therefore be evaluated as an intervention package composed of patient selection, image support, procedural setting, follow-up method, and outcome tracking, not as a single interchangeable injection event. Representative studies that shape contemporary salivary gland botulinum toxin practice are summarized in Table 2.

Table 2. Representative studies shaping contemporary salivary gland botulinum toxin practice

Study	Design / population	Main finding	Technology or public-health relevance
Jost et al. (2019) SIAXI	Randomized adult phase III trial	100 U incobotulinumtoxinA improved salivary flow and global impression of change versus placebo.	Provides dose-anchored adult evidence for chronic neurologic drooling.
Berweck et al. (2021) SIPEXI	Randomized pediatric phase III trial	Weight-adapted ultrasound-guided treatment improved drooling in children with neurologic disorders.	Confirms that pediatric ultrasound-guided pathways can be evidence based, not merely empirical.
Yu et al. (2022)	Systematic review and meta-analysis	Across 17 studies, botulinum toxin improved drooling outcomes in adults and showed supportive pediatric evidence.	Supports broader adoption while highlighting persistent heterogeneity.
Loens et al. (2020)	Localization study	Ultrasound localized glands more reliably than landmark guidance.	Frames ultrasound as a quality and training technology.
Lungren et al. (2016)	10-year tertiary pediatric cohort	Structured ultrasound-guided protocol achieved acceptable effectiveness and safety over 144 procedures.	Demonstrates operational feasibility of repeatable imaging-guided care.
Faria et al. (2015)	Before-after pediatric cohort	Respiratory infections, hospital days, antibiotic days, and chest imaging burden decreased after injection.	Connects secretion control to utilization and respiratory outcomes.
Lindeborg et al. (2025)	Comparative pediatric cohort	With- and without-general-anesthesia pathways had similar quality outcomes; non-GA care lowered cost.	Highlights potential efficiency gains and access benefits.
Bekkers et al. (2020)	Randomized cost-effectiveness trial	BoNT-A was less expensive for one cycle, whereas surgery had greater short-term treatment success.	Clarifies place in a stepwise pathway rather than an all-or-none choice.

3.2. Selecting candidates for injection

The decision to inject should begin with the clinical problem to be solved, not with the procedure itself. Appropriate candidates are patients in whom drooling remains consequential despite conservative support, or in whom medication has failed, produced intolerable anticholinergic effects, or is judged unsuitable because of comorbidity. The most useful pre-procedural questions concern aspiration risk, secretion thickness, caregiver goals, procedural tolerance, and whether symptom control is sought mainly for hygiene, respiratory protection, communication, or postponement of surgery (Daniel et al., 2023; Jost et al., 2023; Yu et al., 2022).

Adult evidence is strongest in Parkinson disease and related neurologic disorders, but clinically relevant data also include stroke and traumatic brain injury populations. In these groups, drooling often compounds dysarthria, social withdrawal, and dysphagia rather than existing as an isolated symptom, which is why otolaryngology assessment can add value beyond the injection itself (Jost et al., 2019; Jost et al., 2023; Yu et al., 2022).

Pediatric decision-making is more context dependent. Cerebral palsy, developmental disorders, genetic syndromes, and other medically complex conditions dominate the literature, yet family capacity for follow-up, aspiration history, the need for sedation, and the hoped-for balance between symptom relief and pulmonary protection often matter as much as age or diagnosis (Berweck et al., 2021; Daniel et al., 2023; Fan et al., 2022).

Separating anterior from posterior drooling remains clinically important because the treatment goal changes. Visible anterior loss mainly drives skin breakdown, clothing changes, and social stigma, whereas posterior pooling raises greater concern for suction burden, recurrent lower respiratory problems, and hospital use (Daniel et al., 2023; Hockstein et al., 2004).

For that reason, pre-procedural work-up should be individualized. When airway protection is uncertain or swallow status is changing, FEES, videofluoroscopy, or structured swallowing assessment may help define whether secretion reduction is likely to help, harm, or require closer follow-up (Daniel et al., 2023; Jost et al., 2023).

3.3. Choosing glands and planning retreatment

Gland targeting is often treated as a routine detail, but in practice it is one of the major sources of variability in outcome. The parotid and submandibular glands both contribute substantially to overall salivary production, yet not equally in all circumstances. The submandibular glands play a particularly important role in resting, unstimulated saliva, which helps explain why they are commonly targeted in chronic drooling. The parotids remain relevant when broader reduction in total secretion burden is needed or when prior submandibular-only treatment has been incomplete (Jost et al., 2023; Lungren et al., 2016).

The controversy over two-gland versus four-gland strategies is unresolved because the comparative literature is heterogeneous and highly context dependent. Bilateral submandibular injection can be effective and may be attractive when clinicians wish to reduce resting saliva while limiting total toxin exposure. Four-gland strategies are widely used in pediatric otolaryngology and tertiary secretion-management programs, particularly when secretion burden is severe or when prior limited strategies have not met goals. Fan et al. reported clinically meaningful benefits of four-gland injections in a very young medically complex cohort, including reductions in pneumonia admissions and anticholinergic use, while many pediatric tertiary protocols routinely combine bilateral parotid and bilateral submandibular targets for broader effect (Fan et al., 2022; Lungren et al., 2016).

A more useful way to think about targeting is as staged optimization rather than doctrinal choice. Clinicians should ask what problem is being targeted, how severe baseline dysphagia is, whether prior response was complete or partial, and whether the adverse-effect profile leaves room to broaden treatment. Repeat treatment is common and should not be interpreted as failure. In real-world care, salivary gland chemodenervation functions more like chronic pathway management than a one-time procedure, with protocol refinement over time based on caregiver feedback, respiratory events, and structured outcomes (Berweck et al., 2021; Jost et al., 2020; Jost et al., 2023).

This iterative perspective also matters from a quality-improvement standpoint. When targeting decisions are standardized and documented, centers can compare protocols, audit outcomes, and train new injectors more reliably. If target selection remains informal, learning is lost between cycles. Gland targeting is therefore not only a physiologic question but also an information-management question.

3.4. Ultrasound guidance, standardization, and care setting

Ultrasound guidance is one of the clearest reasons this topic belongs in a technology-oriented journal. It converts injection from a predominantly experience-based act into an image-guided intervention that can be visualized, documented, standardized, taught, and audited. For small pediatric glands, altered anatomy, or previously operated necks, the benefit is intuitive. But even in more routine cases, ultrasound can improve injector confidence, reduce uncertainty about depth and gland borders, and strengthen reproducibility between operators (Jost et al., 2023; Loens et al., 2020; Lungren et al., 2016).

Loens et al. addressed this question directly by comparing ultrasound with landmark-based localization and demonstrated a clear sonographic advantage for identifying salivary glands. That finding does not by itself prove universal superiority on every clinical endpoint, but it does show that landmark guidance cannot be assumed to be equally reliable, especially if the goal is standardization across different anatomies and clinicians. In health-technology terms, ultrasound improves process fidelity even where outcome superiority still needs further comparative study (Loens et al., 2020).

The pediatric tertiary-care experience reported by Lungren et al. is especially informative because it shows how ultrasound guidance functions under real clinical conditions. Across 111 children and 144 procedures over ten years, the authors described a structured, weight-based, ultrasound-guided protocol with acceptable effectiveness and safety. The important lesson is not only that the injections worked, but that an imaging-supported workflow made repeatable care possible in a complex hospital population. That operational dimension is essential when thinking about implementation rather than isolated procedure success (Lungren et al., 2016).

Ultrasound guidance is also valuable for training and governance. Saved images can support supervision, help teach anatomy to fellows and residents, and improve protocol adherence when centers formalize standard operating procedures. This creates a foundation for competency-based procedural education rather than apprenticeship by intuition alone. It also makes it easier to harmonize practice across otolaryngology, radiology, pediatric neurology, and rehabilitation when drooling services are shared.

A second technology-related issue is the procedural setting. Historically, many pediatric injections were performed under general anesthesia. Lindeborg et al. compared pediatric injections performed with and without general anesthesia and found no statistically significant differences in post-injection quality outcomes, aspiration pneumonia admissions, or progression to surgery, while the non-general-anesthesia pathway offered lower cost and potential access benefits. For health-system design this is highly relevant: reducing anesthesia dependence can shorten waits, lower costs, reduce family disruption, and expand treatment capacity if the local team has the procedural expertise to do so safely (Lindeborg et al., 2025).

From a public-health perspective, then, ultrasound guidance is not only about accuracy. It is also about service architecture. It supports decentralization from operating-room pathways to clinic or procedure-room pathways where feasible, lowers reliance on scarce anesthesia resources, and creates the conditions for auditable minimally invasive care. Those benefits may be especially important in systems facing pediatric anesthesia bottlenecks, geographic inequity, or high caregiver opportunity costs.

3.5. Formulation-specific dosing, endpoints, and follow-up

Formulation and dose must be discussed cautiously because the evidence is formulation specific and not fully interchangeable across toxin products. The adult SIAXI trial established strong randomized evidence for incobotulinumtoxinA in chronic sialorrhea, with the 100 U regimen demonstrating significant benefit over placebo in salivary flow reduction and global impression of change, and a sustained effect observed up to 16 weeks. In the pediatric SIPEXI program, weight-adapted doses up to 75 U with ultrasound guidance also demonstrated efficacy and tolerability across repeated cycles. These trials provide a backbone for contemporary practice, but they do not justify casual equivalence claims between all toxin preparations or all patient groups (Berweck et al., 2021; Jost et al., 2019).

Long-term management is equally important because sialorrhea is rarely solved by one cycle. In the 64-week extension reported by Jost et al., repeated incobotulinumtoxinA cycles maintained benefit in unstimulated salivary flow and patient-reported drooling outcomes, while speech and swallowing scores remained stable and no additional safety signal emerged. For clinicians and planners, the key question is not whether one injection works at four weeks, but whether a repeatable program can maintain benefit without unacceptable cumulative burden (Jost et al., 2020).

Outcome assessment remains one of the field's biggest methodological weaknesses. Sforza et al. identified 19 pediatric drooling outcome measures across 21 studies, highlighting why comparison across

studies remains difficult. Some tools emphasize physiology, others caregiver impact, and still others broad clinical impression. Without a core outcome set, the field risks measuring what is easiest rather than what matters most to patients, caregivers, and health systems (Sforza et al., 2022).

Physiologic and clinician-rated measures still have value. Salivary flow rates, drooling severity scales, and frequency scales demonstrate biologic effect and are helpful for short-term monitoring. Yet they are insufficient as stand-alone endpoints. A treatment that modestly lowers measured saliva but clearly reduces suctioning, school disruption, or caregiver workload may still represent major success. Conversely, a strong physiologic response that produces troublesome thick secretions may be unacceptable (Jost et al., 2019; Yu et al., 2022).

For this reason, patient- and caregiver-reported outcomes deserve more prominence. Reid et al. developed the Drooling Impact Scale as a responsive and reliable measure of how drooling affects daily life in children with developmental disabilities. This tool is particularly valuable because it captures domains that matter deeply to families but are often underrepresented in procedural studies, including clothing changes, social embarrassment, skin care, and daily management. In public-health terms, such measures help translate clinical intervention into lived function and caregiver labor (Reid et al., 2010; Sforza et al., 2022).

Respiratory and utilization outcomes are the next frontier. Faria et al. compared 180-day pre- and post-injection periods in neurologically impaired children and found encouraging reductions in respiratory infections, hospital days, antibiotic days, chest radiographs, and infiltrates. Fan et al. likewise reported fewer pneumonia admissions and reduced anticholinergic use after four-gland injection in very young children. These studies are observational and should not be overinterpreted as definitive population-level proof, but they are important because they connect secretion management with endpoints that matter to families, hospitals, and payers (Fan et al., 2022; Faria et al., 2015).

A pragmatic implication is that outcome collection should increasingly be treated as a digital quality task. If centers systematically capture drooling severity, caregiver burden, adverse effects, aspiration-related admissions, medication changes, and retreatment intervals in registry-ready formats, they can generate stronger real-world evidence while simultaneously improving practice.

3.6. Effectiveness and safety profile

The broad efficacy signal across the literature is favorable. Yu et al. pooled 17 studies involving 981 patients and concluded that both botulinum toxin A and B reduce drooling frequency and severity, lower saliva output, and improve global impression of change in adults, with more limited but still supportive evidence in children. The authors judged the certainty of evidence to be moderate in adults but lower in pediatric settings, which is an important reminder that “effective” does not mean equally well quantified in all populations (Yu et al., 2022).

The adult randomized evidence is led by SIAXI. In that trial, 184 adults with chronic sialorrhea due to Parkinson disease, atypical parkinsonism, stroke, or traumatic brain injury were randomized to placebo, 75 U, or 100 U incobotulinumtoxinA. The 100 U dose demonstrated significant benefit versus placebo on both coprimary endpoints, and the benefit extended to week 16. These data move adult treatment beyond uncontrolled experience and provide one of the clearest dose-anchored evidence bases in the field (Jost et al., 2019).

The pediatric randomized evidence is led by SIPEXI. Berweck et al. showed superiority of incobotulinumtoxinA over placebo in children aged 6 to 17 years with neurologic disorders, using weight-adapted ultrasound-guided injections, with benefit maintained over repeated cycles. This trial is especially useful for otolaryngology because it confirms that pediatric ultrasound-guided salivary gland injection now rests on high-level evidence rather than tertiary-center tradition alone (Berweck et al., 2021).

Safety, however, must be discussed realistically. Dry mouth, dysphagia, thickened secretions, and transient worsening of swallow function are the most relevant adverse effects. In SIAXI, dry mouth and dysphagia were the most frequent treatment-related events, while the 64-week extension did not reveal additional safety concerns over time. High-risk neuromuscular patients, children with major secretion-thickening problems, and patients with poorly compensated swallowing dysfunction require special caution. The correct interpretation is not that botulinum toxin is universally “safe,” but that it appears acceptably safe when embedded in careful selection and monitoring pathways (Jost et al., 2019; Jost et al., 2020; Jost et al., 2023).

This balance between efficacy and caution is exactly why multidisciplinary delivery matters. A service that offers injections without structured follow-up may underestimate dysphagia, xerostomia, or respiratory change. By contrast, a pathway that includes baseline swallow assessment when indicated, caregiver education, and repeat review can preserve the benefit-risk ratio while learning from each cycle. Technology alone is not enough; implementation quality determines how safely the technology performs.

3.7. Public-health, service-delivery, and equity implications

The public-health importance of salivary gland botulinum toxin lies in the possibility that a targeted procedure may alter downstream burdens that are otherwise exhausting, costly, and socially isolating. Families caring for children or adults with severe drooling often describe routines structured around bib changes, skin care, suctioning, repeated wiping, medication management, and vigilance for respiratory decline. These tasks consume time, money, and emotional capacity, yet they are rarely visible in conventional procedural outcome papers. Incorporating caregiver impact into evaluation is therefore not optional if the intervention is to be assessed honestly (Hockstein et al., 2004; Reid et al., 2010).

Respiratory morbidity is one of the most compelling domains. Observational data suggest that selected patients may experience fewer aspiration-related admissions, fewer antibiotic days, and fewer respiratory evaluations after injection. Even if these studies cannot yet establish definitive population-level causality, they identify a plausible mechanism by which secretion control could reduce preventable healthcare use. For public systems managing high-cost pediatric or neurologic populations, that possibility deserves prospective study and better routine monitoring (Fan et al., 2022; Faria et al., 2015).

Medication burden is another practical endpoint. Systemic anticholinergics remain important in drooling management, but they are limited by constipation, urinary retention, blurred vision, drowsiness, and cognitive effects, which are especially problematic in neurologically vulnerable patients. Fan et al. reported reduced anticholinergic use after four-gland pediatric injection, supporting the idea that local gland-directed therapy can sometimes serve as an anticholinergic-sparing strategy rather than merely an add-on procedure (Fan et al., 2022).

Cost and service delivery are increasingly relevant as more centers adopt injection therapy. Bekkers et al. compared botulinum neurotoxin A with surgery in a randomized pediatric trial and found that BoNT-A was less expensive for one treatment cycle, whereas surgery achieved greater short-term treatment success at 32 weeks. This does not diminish the importance of botulinum toxin; rather, it clarifies its place in a stepwise pathway. A less invasive and less expensive intervention may be entirely appropriate earlier in care, particularly when families value reversibility, diagnostic trialing, or avoidance of surgery (Bekkers et al., 2020).

Lindeborg et al. extend this service-delivery discussion by showing that pediatric injections performed without general anesthesia can achieve similar quality outcomes with lower costs and potential access benefits. This finding is strategically important for systems trying to reduce procedural bottlenecks. General anesthesia consumes scarce resources, increases logistical burden, and can prolong waiting times. When ultrasound-guided office or bedside treatment is feasible, the intervention becomes not only clinically attractive but operationally strategic (Lindeborg et al., 2025).

Equity also deserves explicit attention. Fan et al. reported that 73.5% of their under-three cohort came from medically underserved areas or populations, and the authors noted disproportionate impact in medically underserved Black patients. These findings should not be generalized carelessly, but they raise a crucial implementation question: the populations with the greatest burden of chronic drooling may not be the ones with easiest access to specialist ENT, ultrasound-guided procedures, or multidisciplinary saliva-control teams. Technology improves care only if it can be delivered fairly (Fan et al., 2022).

A final public-health theme is pathway integration. Orriëns et al. described an interdisciplinary saliva-control team and a stepwise algorithm shaped by repeated assessment, family preferences, and cross-specialty input. That model suggests a broader lesson: the value of botulinum toxin is greatest when it is embedded in a learning system that can escalate, de-escalate, combine, or redirect therapy over time. In that respect, the future of drooling management is as much about care design as about drug efficacy (Daniel et al., 2023; Orriëns et al., 2024).

3.8. Where botulinum toxin fits in the treatment pathway

Botulinum toxin should be positioned within a stepwise treatment algorithm rather than discussed in isolation. Conservative management remains important and includes caregiver education, behavioral prompting where developmentally feasible, positioning strategies, adaptive seating, oral-motor and speech therapy, barrier skin care, suction tools, and practical school or home accommodations. These measures are often insufficient on their own in severe neurologic drooling, but they still shape candidacy for invasive treatment because they clarify whether the principal problem is secretion volume, oral motor clearance, posture, or the environmental context in which the patient functions (Daniel et al., 2023; Hockstein et al., 2004; Orriëns et al., 2024).

Pharmacologic therapy also remains relevant. Anticholinergics are commonly used earlier in the pathway because they are accessible and do not require procedural expertise. However, their systemic adverse-

effect profile can make them unsuitable for long-term use in many patients. For some families, botulinum toxin becomes attractive not because it is abstractly stronger than medication, but because it localizes treatment and may reduce dependence on drugs whose side effects compromise daily life (Daniel et al., 2023; Fan et al., 2022; Jost et al., 2023).

Surgery remains essential for refractory cases, but the contemporary literature supports seeing botulinum toxin as a useful intermediary rather than a lesser substitute. Because the injection effect is time limited and adjustable, it can clarify whether secretion reduction actually improves the outcomes the family values before permanent surgery is considered. In this sense, gland injection functions as both therapy and decision aid. If benefit is meaningful but repeated procedures become burdensome, surgery may become more acceptable. If benefit is partial or adverse effects are problematic, the pathway can be redirected without committing to irreversible intervention (Bekkers et al., 2020; Daniel et al., 2023; Orriëns et al., 2024).

Bekkers et al. provide a helpful economic perspective on this sequencing question. Two-duct ligation produced greater success at 32 weeks but at higher cost, whereas BoNT-A was less expensive for a single cycle. For health systems, that suggests a rational sequencing logic: reversible, lower-cost, lower-commitment therapy may be appropriate earlier in the pathway, while more invasive and potentially more durable procedures may be reserved for patients whose goals are not met with repeat injections or whose treatment burden becomes too high (Bekkers et al., 2020).

A stepwise algorithm also allows services to match treatment intensity to the patient's social context. A child whose drooling mainly interferes with school participation may require a different threshold for escalation than a child with recurrent aspiration pneumonia, or an adult whose dominant complaint is communication-related stigma. Ultrasound-guided botulinum toxin fits this individualized philosophy well because target pattern, dose, setting, and retreatment interval can all be adapted and then re-evaluated with structured outcomes.

4. Discussion

Across the literature, one message is consistent: salivary gland botulinum toxin offers a credible low-invasiveness option for patients whose drooling continues to create hygiene, respiratory, or caregiver burden despite first-line measures. The evidence is no longer confined to small case series. Randomized trials, consensus recommendations, and longer follow-up studies now support its role within multidisciplinary drooling care (Berweck et al., 2021; Daniel et al., 2023; Jost et al., 2019; Yu et al., 2022).

Imaging deserves particular emphasis because it changes more than needle placement. Ultrasound makes anatomy visible, supports reproducible documentation, and gives programs a practical way to teach and audit technique. For a journal such as IJITSS, that matters because ultrasound functions here as a scalable health technology, not merely as a convenience for expert operators (Jost et al., 2023; Loens et al., 2020; Lungren et al., 2016).

The setting of care is another strategic issue. When safe non-general-anesthesia or office-based pathways are available, the intervention may impose less disruption on families, avoid operating-room bottlenecks, and lower costs. Those service-level gains are especially relevant in children and in regions where anesthesia access or theatre time is a major constraint (Bekkers et al., 2020; Lindeborg et al., 2025).

A third implication concerns what outcomes are counted. The field already demonstrates reductions in saliva and drooling severity, but publication-quality progress now depends on more consistent reporting of caregiver time, respiratory events, antibiotic exposure, dysphagia change, school participation, and health-service use. Without those measures, it remains difficult to compare programs or make policy claims (Faria et al., 2015; Reid et al., 2010; Sforza et al., 2022).

Equity should also be brought closer to the center of the discussion. Specialty injection services are unevenly distributed, and the patients with the greatest burden may also face transport barriers, longer waits, or inconsistent referral into multidisciplinary care. A technology can widen disparities if access to that technology is patterned by geography or socioeconomic position (Fan et al., 2022; Orriëns et al., 2024).

This is why team-based care matters. ENT, neurology, rehabilitation, speech and language therapy, pediatrics, nursing, and caregivers each contribute information that affects target selection, timing, risk assessment, and the definition of success. The strongest service models treat injection as one step in a monitored pathway rather than as a standalone procedure (Daniel et al., 2023; Orriëns et al., 2024).

The evidence base nevertheless remains uneven. Populations, toxin products, dosing schemes, target-gland combinations, and follow-up intervals differ across studies. Many reports are observational, and

respiratory, economic, and equity outcomes remain less mature than efficacy endpoints (Sforza et al., 2022; Yu et al., 2022).

Future work should therefore prioritize comparative studies of injection strategies, shared core outcome sets, implementation studies of ultrasound-supported office pathways, and better evaluation of who gains access to treatment and who does not. Those questions align closely with the journal's interest in how technology changes care delivery at the system level (Lindeborg et al., 2025; Loens et al., 2020; Sforza et al., 2022).

Table 3. Technology and public-health priorities for implementation-oriented drooling services

Domain	Current challenge	Why it matters for IJITSS	Practical metric for future studies
Imaging guidance	Variable experience and informal targeting workflows	Ultrasound is a scalable procedural technology with training and governance value.	Localization success, adverse events, archived image completeness
Procedural setting	Heavy reliance on general anesthesia in some systems	Non-GA pathways may reduce waiting times, cost, and caregiver disruption.	Procedure completion rate, direct cost, anesthesia exposure
Outcome measurement	Too many nonstandard outcome tools	Poor comparability limits evidence synthesis and policy translation.	Core dataset completion, DIS change, respiratory utilization
Equity	Access may be worse for underserved or distant populations	Technology only improves health if referral pathways are fair and usable.	Travel distance, wait time, no-show rate, underserved-area representation
Caregiver burden	Often measured inconsistently or omitted	Invisible care work should be part of value assessment.	Caregiver-reported burden, garment changes, suction frequency
Quality improvement	Repeat treatment cycles often poorly documented	Registry-ready care can turn routine practice into learning systems.	Retreatment interval, protocol adherence, medication-sparing outcomes

5. Conclusions

Salivary gland botulinum toxin should now be viewed as an established component of chronic sialorrhea management rather than as a niche rescue option. Its value is greatest when injection is embedded in a structured pathway that links patient selection, gland choice, ultrasound-supported technique, and follow-up outcomes that matter to patients, caregivers, and health systems. The next step for the field is not simply more proof that drooling can be reduced, but better standardization of endpoints, wider access to office-based ultrasound-guided services, and stronger implementation research on respiratory, economic, and equity outcomes.

Acknowledgments

The authors acknowledge the contribution of all participating institutions and co-authors to the preparation of this narrative review.

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All authors have read and approved the final version of the manuscript.

Funding: The authors received no specific funding for this work.

Conflicts of Interest: No conflicts of interest to declare.

Ethics statement: Ethics approval was not required because this manuscript is a narrative review of previously published literature and did not involve direct research on human participants or animals.

Data availability statement: No new datasets were generated or analyzed for this review. All data discussed in the manuscript come from previously published sources cited in the reference list.

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