International Journal of Pediatric Otorhinolaryngology 116 (2019) 43–48

Contents lists available at ScienceDirect

International Journal of Pediatric Otorhinolaryngology

journal homepage: www.elsevier.com/locate/ijporl

Management of velopharyngeal dysfunction in patients with 22q11.2 deletion syndrome: A survey of practice patterns☆

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ARTICLE INFO

The data included in this manuscript was presented at The Ninth Biennial International 22q11.2 Deletion Syndrome Meeting in Mallorca, Spain on June 20, 2014, at the Annual Meeting of the Society for Ear Nose and Throat Advances in Children in St. Louis, MO on December 5, 2014, and at the 72nd Annual Meeting of the American Cleft Palate – Craniofacial Association in Palm Springs, California on April 22, 2015.

Keywords:
22q11.2 deletion
Velopharyngeal dysfunction
Survey
Practice patterns

ABSTRACT

Objective: To determine demographics and practice patterns of surgeons treating velopharyngeal dysfunction (VPD) in patients with 22q11.2 deletion syndrome (22q11.2DS).
Methods: An anonymous electronic survey study was administered to the surgical membership of the American Cleft Palate-Craniofacial Association and the Society for Ear Nose and Throat Advances in Children. The survey queried surgeon demographics and differences in management practices for submucous cleft palate (SMCP), pharyngoplasty algorithms, and self-reported complications for nonsyndromic versus 22q11.2DS patients.
Results: 126 surveys were returned from 9 international regions with the majority from the United States (73%), followed by Western Europe (9.5%) and Canada (7.9%). Plastic surgery was the most common specialty (61.9%), followed by otolaryngology (27.8%). 88.1% reported fellowship training, and 33% completed multiple fellowships. Prior to proceeding with pharyngoplasty in 22q11.2DS patients, surgeons required the following assessments: speech evaluation (79.4%), velopharyngeal imaging (51.6%), cardiac evaluation (50.0%), carotid artery MRI (29.4%), and cervical spine x-rays (11.1%). Nasoendoscopy was the most common modality used for imaging the velopharynx. Overall, providers managed patients with 22q11.2DS similarly to nonsyndromic patients, with several significant exceptions including that they were more likely to perform SMCP repair alone as a first approach in nonsyndromic patients ($p = 0.031$) and posterior pharyngeal flap without SMCP repair in those with 22q11.2DS ($p = 0.017$).
Conclusions: Practice patterns for the management of VPD in patients with 22q11.2DS vary across providers. Further collaborative studies are needed to develop optimal treatment paradigms for VPD in patients with 22q11.2 DS.

1. Introduction

Velopharyngeal dysfunction (VPD) is a clinical finding referring to the incomplete closure of the nasal airway during speech production that does not indicate a specific etiology. VPD may present as hypernasality, nasal emission, or nasal turbulence, with compensatory mechanisms leading to nasal grimacing and speech errors [1]. Causes of VPD are multifactorial, and include anatomic and myoneurogenic mechanisms, and mislearning of speech. VPD is considered a hallmark of 22q11.2 deletion syndrome (22q11.2DS), independent of the presence or absence of overt palatal clefting [2,3]. Congenital VPD in this population may result from velopharyngeal disproportion, characterized by structural anomalies, such as a deep and/or wide pharynx as well as dysfunction of the musculature of speech [2,4,5].

22q11.2DS has an estimated prevalence of 1 in every 2000 to 4000 live births in the Unites States, although under-diagnosis is suspected due to its clinical variability [6,7]. For instance, a recent European study identified 22q11.2DS in 1 out of 992 unselected fetuses (without cardiac or palatal anomalies) [8,9]. Presentation of 22q11.2DS is variable, but a diagnosis of 22q11.2DS may be suspected in patients with congenital heart disease, palatal abnormalities, hypocalcemia, immune deficiency, learning difficulties, and characteristic facial features [2,10]. Patients with 22q11.2DS often present either in infancy with cardiac defects, or later with speech disorders and learning

☆ This study was reviewed and exempted from Institutional Review Board approval at the Children's Hospital of Philadelphia.

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https://doi.org/10.1016/j.ijporl.2018.10.016
Received 19 May 2018; Received in revised form 9 October 2018; Accepted 10 October 2018
Available online 12 October 2018
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Table 1
Practice location and specialty.

Practice Location	Total N (%)	Plastic Surgery	ENT	OMFS	Pediatric Surgery	Other	Multiple[b]
Total	126	78 (61.9%)	35 (27.8%)	6 (4.8%)	1 (0.8%)	1 (0.8%)	5 (4%)
International Regions:							
United States	92 (73%)	56 (60.9%)	31 (33.7%)	2 (2.2%)	0	1 (1.1%)	2 (2.2%)
Western Europe	12 (9.5%)	6 (50%)	1 (8.3%)	2 (16.7%)	1 (8.3%)	0	2 (16.7%)
Canada	10 (7.9%)	7 (70%)	2 (20.0%)	1 (10%)	0	0	0
Asia[a]	3 (2.4%)	1 (33.3%)	1 (33.3%)	1 (33.3%)	0	0	0
Australia	3 (2.4%)	3 (100%)	0	0	0	0	0
Central/South America	3 (2.4%)	2 (66.6%)	0	0	0	0	1(33.3%)
Africa[a]	1 (0.8%)	0	0	1 (100%)	0	0	0
Eastern Europe	1 (0.8%)	1 (100%)	0	0	0	0	0
New Zealand	1 (0.8%)	1 (0.8%)	0	0	0	0	0
"Overseas various countries"	1 (0.8%)	1 (0.8%)	0	0	0	0	0
US Regions:							
Midwest	32 (25.4%)	21 (65.6%)	10 (31.3%)	0	0	0	1 (3.1%)
Northeast	21 (16.7%)	16 (76.2%)	5 (23.8%)	0	0	0	0
West/Northwest	19 (15.1%)	10 (52.6%)	7 (36.8%)	0	0	1 (5.3%)	1 (5.2%)
Southeast	17 (13.5%)	6 (35.3%)	9 (52.9%)	2 (11.8%)	0	0	0
Southwest	3 (2.4%)	3 (100%)	0	0	0	0	0

[a] One OMFS surgeon works in both Africa and Asia.
[b] Multiple specialists include plastics/ENT, plastics/OMFS, plastics/OMFS/pediatric surgery, plastics/pediatric surgery, and ENT/other (facial plastics).

difficulties [3]. Up to 75% of patients have palatal involvement, which includes overt cleft palate (11%), submucous cleft palate (SMCP), and velopharyngeal dysfunction in the absence of clefting [2,11]. In addition to these more common presenting symptoms, patients with 22q11.2DS may have other comorbidities including cervical spine and cervical vascular anomalies, which can increase their risks during surgery and may require increased screening and different surgical algorithms for the treatment of VPD [12].

Management of VPD in 22q11.2DS is often complicated. Although there is great variability, VPD in patients with 22q11.2DS tends to be more severe and persistent than in other populations [13,14]. Anatomic findings in patients with severe VPD typically include large velopharyngeal gaps and poor velopharyngeal motion. Consequently, alterations in surgical techniques have been suggested to more successfully achieve velopharyngeal competence in this group [13,15]. The first repair of SMCP may be less successful at completely treating VPD, resulting in the need for additional speech surgeries in childhood and adolescence [16–18] According to a recent cross-sectional cohort study of speech outcomes in those with 22q11.2DS, only 34% of the 50 adolescents and young adults included attained normal speech ratings, and about 46% underwent pharyngoplasties [19]. Pharyngoplasties for severe VPD carry increased risks for obstructive sleep apnea, and patients with 22q11.2DS have been reported to have a higher prevalence of obstructive sleep apnea compared to the general pediatric population [20].

The literature offers several suggested treatment algorithms for VPD in this patient population; however, current knowledge of how the majority of physicians are currently treating VPD is limited [12,13,17,21] Greater understanding of the effects of various treatment algorithms is required to successfully manage VPD and minimize the risk of surgical complications in patients with 22q11.2DS. This survey study reports on demographics and practice patterns of surgeons treating VPD in patients with 22q11.2 DS, with the goal to better understand how the majority of surgeons approach management of VPD in this complex patient population.

2. Methods

A survey study was performed after IRB exemption was obtained from our institution. An anonymous electronic survey was administered to the surgical membership of the American Cleft Palate-Craniofacial Association (ACPA) and the Society for Ear Nose and Throat Advances in Children (SENTAC) using REDCap (Research Electronic Data Capture), a secure, web-based application designed exclusively to support data capture for research studies. The survey was resent two weeks after the initial request. Only completed surveys and those where the respondents reported treating patients with clefts and patients with 22q11.2DS were included for analysis.

Respondents were asked to comment on practice demographics, management preferences for SMCP, pharyngoplasty algorithms, and self-reported complications. Demographic questions addressed surgeon specialty, fellowship training, geographic region, practice setting, location, and volume. Questions regarding the management of SMCP queried the timing and choice of surgical intervention. Those addressing pharyngoplasty algorithms focused on preferences for velopharyngeal imaging, mandatory pre-operative testing requirements prior to pharyngoplasty in 22q11.2DS, and approach to the upper airway in both nonsyndromic patients and patients with 22q11.2DS. Additional information was gathered in this survey but is not reviewed in this paper.

This paper summarizes the survey results with descriptive statistics and focuses on differences in clinical management practices for nonsyndromic versus 22q11.2DS patients. Questions regarding management of SCMP and pharyngoplasty algorithms were examined using McNemar's exact tests to determine the effect of a diagnosis of 22q11.2DS. Stata, Version 13 (Texas, USA) was used for analysis.

3. Results

3.1. Demographics

A total of 179 surveys were returned, but 53 were excluded for the following reasons: 7 were incomplete, 41 of the respondents did not treat patients with clefts, and 5 did not treat patients with 22q11.2DS. Thus, a total of 126 surveys were included in the analysis.

Plastic surgery was the most common specialty selected by 61.9% of respondents, followed by otolaryngology (ENT, 27.8%), and oromaxillofacial surgery (OMFS, 4.8%). One respondent self-listed as facial plastics, and five selected multiple specialties [Table 1]. One hundred eleven (88.1%) were fellowship trained and 41 (32.5%) had completed multiple fellowships. The most common fellowship training selected was craniofacial surgery (55.5%), followed by pediatric plastic surgery (37.3%), and pediatric ENT (23.8%). Other fellowships included pediatric surgery (5), cleft surgery (1), facial plastic surgery (2), neurosurgery (1), hand and microsurgery (1), and head and neck surgery (1). Of those who completed multiple fellowships, 36 completed 2

Table 2
Practice demographics.

Practice Type	
Academic medical center	80 (63.5%)
Combined private/academic medical center	26 (20.6%)
Private Practice	14 (11.1%)
Other	5 (4.0%)
Practice Location	
Urban	105 (83.3%)
Suburban	18 (14.3%)
Large rural (pop: 25,000–49,000)	3 (2.4%)
Small rural (pop: 10,000–25,000)	0 (0.0%)
Isolated rural (pop: 2.500-10,000)	0 (0.0%)
Number patients with 22q evaluated per month	
0	12 (9.5%)
1 to 2	77 (61.1%)
3 to 5	23 (18.3%)
5 to 10	9 (7.1%)
10 to 20	3 (2.4%)

fellowships, 4 completed 3 fellowships, and 1 completed 4 fellowships.

The majority of surgeons were from the United States (US, 73%), followed by Western Europe (9.5%), and Canada (7.9%) [Table 1]. Within the United States, surgeons specialized in plastic surgery (61%), followed by ENT (34%), and OMFS (2%). These ratios were similar in Canada (70%, 20%, and 10% respectively), whereas in Western Europe, 50% specialized in plastic surgery, 8% ENT, 17% OMFS, 8% multiple, and 17% other. Within the United States, plastic surgeons were most heavily represented in the Southwest (100%), followed by the Northeast (76.2%), Midwest (65.6%), and West/Northwest (52.6%). Whereas in the Southeast, ENTs were more common (52.9%) than plastic surgeons (35.3%). The majority of respondents worked in an academic setting (63.5%) and in an urban location (83.3%) [Table 2]. Only 24.6% reported that their hospital had a dedicated 22q Center. Respondents from the Midwest reported the highest number of 22q11.2DS treatment centers (n = 13), followed by respondents in the Northeast (n = 6), West (n = 3), and Southeast (1) and Southwest (1). Internationally, five centers were reported in Western Europe and two in Central/South America.

3.2. Management of SMCP

For management of SMCP in infancy, the majority reported waiting for speech to emerge before proceeding with treatment in both 22q11.2DS and nonsyndromic patients (77.8% and 83.3%, respectively). 20.6% of respondents did, however, report proceeding with SMCP repair in infancy for patients with 22q11.2DS, and 17.5% for nonsyndromic patients. When nonsyndromic patients were compared with those with 22q11.2DS, surgeons were more likely to perform SMCP repair alone as the first approach in nonsyndromic patients (p = 0.031), whereas surgeons were significantly more likely to perform posterior pharyngeal flap without SMCP repair in those with 22q11.2DS (p = 0.017) [Table 3].

3.3. Pre-operative assessments

Nasoendoscopy was the most common modality used for imaging the velopharynx in both patients with 22q11.2DS and nonsyndromic patients (92.1% and 88.9%) [Table 4]. Prior to proceeding with pharyngoplasty for VPD in 22q11.2DS patients, surgeons required the following evaluations: speech evaluation (79.4%), velopharyngeal imaging (51.6%), cardiac evaluation (50.0%), carotid artery MRI (29.4%), and cervical spine x-rays (11.1%). In nonsyndromic patients, 6.3% of surgeons did not use routine pre-operative imaging of the velopharynx, whereas in patients with 22q11.2DS, less than 1% of surgeons did not use any velopharyngeal imaging. This represents a significant difference in management between the two groups (p = 0.016).

Table 3
Management of submucous cleft palate.

General Management of SMCP in Infants		
	22q11.2DS	*Nonsyndromic*
Repair SMCP in infancy	26 (20.6%)	22 (17.5%)
Perform SMCP/PPF in infancy	2 (1.6%)	1 (0.8%)
Perform SMCP/SPP in infancy	1 (0.8%)	1 (0.8%)
Wait until speech emerges	98 (77.8%)	105 (83.3%)
Base treatment on imaging	7 (5.6%)	2 (1.6%)
Other	4 (3.2%)	5 (4.0%)
General Management of SMCP in Verbal Children		
	22q11.2DS	*Nonsyndromic*
Perform SMCP repair alone*	52 (41.3%)	64 (50.8%)
Perform combined SMCP/PPF	5 (4.0%)	3 (2.4%)
Perform combined SMCP/SPP	9 (7.1%)	5 (4.0%)
Perform PPF without SMCP repair**	8 (6.3%)	2 (1.6%)
Perform SPP without SMCP repair	1 (0.8%)	1 (0.8%)
Base decision on imaging	30 (23.8%)	26 (20.6%)
Base treatment on severity	65 (51.6%)	60 (47.6%)
Other	5 (4.0%)	6 (4.8%)

SMCP = submucous cleft palate, PPF = posterior pharyngeal flap.
SPP = sphincterpharyngoplasty
*Surgeons were more likely to perform SMCP repair alone as first approach in nonsyndromic patients (p = 0.031).
**Surgeons were significantly more likely to perform PPF without SMCP repair in those with 22q11.2DS (p = 0.017).

Table 4
Pre-operative assessments.

Pre-operative Imaging of the Velopharynx		
	22q11.2DS	*Nonsyndromic*
No routine pre-op of velopharynx*	1 (0.8%)	8 (6.3%)
Nasoendoscopy	116 (92.1%)	112 (88.9%)
Video fluoroscopy	35 (27.8%)	30 (23.8%)
Lateral neck x-rays	6 (4.8%)	5 (4.0%)
Other	4 (3.2%)	2 (1.6%)
Mandatory Testing Prior to Pharyngoplasty in 22q11.2DS		
None	4 (3.2%)	
Cervical MRI for carotid artery assessment	37 (29.4%)	
Cervical spine x-rays or orthopedic clearance	14 (11.1%)	
Sleep study	20 (15.9%)	
Endocrine evaluation	6 (4.8%)	
Speech evaluation	100 (79.4%)	
Cardiac evaluation	63 (50.0%)	
Velopharyngeal imaging	65 (51.6%)	
Other	11 (8.7%)	

*Surgeons reported not using routine pre-op imaging of the velopharynx significantly more in nonsyndromic patients (p = 0.016).

3.4. Airway management

When screening protocols for obstructive sleep apnea (OSA) were queried, the majority of surgeons said they directly asked about symptoms routinely in 22q11.2DS (77.8%) and nonsyndromic patients (78.6%), while a smaller percentage used a sleep questionnaire (14.3% and 12.7%, respectively). Some surgeons reported using a sleep study preoperatively only when symptoms were present (60.3% and 61.9%, respectively), and postoperatively only when symptoms were present (46.8% in both patient populations) [Table 5].

Few surgeons recommended tonsillectomy in all patients (2.4% and 3.2%, in 22q11.2DS and nonsyndromic patients, respectively). The presence of symptoms indicating airway obstruction was the most common reason that tonsillectomy was recommended in both 22q11.2 and nonsyndromic patients (42.9% and 42.1%). If tonsillectomy was recommended, over half recommended it occur prior to pharyngoplasty

Table 5
Upper airway management.

Obstructive Sleep Apnea Screening		
	22q11.2DS	*Nonsyndromic*
Sleep questionnaire	18 (14.3%)	16 (12.7%)
Ask about symptoms routinely	98 (77.8%)	99 (78.6%)
Pre-op PSG only when symptoms present	76 (60.3%)	78 (61.9%)
Pre-op PSG on all patients	14 (11.1%)	11 (8.7%)
Post-op PSG on all patients	9 (7.1%)	6 (4.8%)
Pre-op PSG when T/A appear enlarged	6 (4.8%)	4 (3.2%)
Depends on procedure	15 (11.9%)	10 (7.9%)
Post-op PSG when symptoms are present	59 (46.8%)	59 (46.8%)
Tonsillectomy		
	22q11.2DS	*Nonsyndromic*
Yes in all patients	3 (2.4%)	4 (3.2%)
Depends on VPI procedure	24 (19.0%)	25 (19.8%)
When tonsils appear enlarged	47 (37.3%)	49 (38.9%)
Symptoms of airway obstruction	54 (42.9%)	53 (42.1%)
When positive sleep study	43 (34.1%)	38 (30.2%)
No	22 (17.5%)	23 (18.3%)
If recommended, w/VPD/VPI surgery	9 (7.1%)	9 (7.1%)
If recommended, prior to surgery	67 (53.2%)	65 (51.6%)
Adenoidectomy		
	22q11.2DS	*Nonsyndromic*
Yes in all patients	11 (8.7%)	12 (9.5%)
Depends on VPI procedure	21 (16.7%)	21 (16.7%)
When adenoids appear enlarged	34 (27.0%)	33 (26.2%)
Symptoms of airway obstruction	34 (27.0%)	36 (28.6%)
Positive sleep study	23 (18.3%)	24 (19.0%)
No	42 (33.3%)	42 (33.3%)
If recommended, only partial adenoidectomy is advised	28 (22.2%)	29 (23.0%)
If recommended, complete adenoidectomy is advised	23 (18.3%)	23 (18.3%)

(53.2% 22q11.2DS and 51.6% nonsyndromic patients), whereas 7.1% of surgeons recommended a simultaneous procedure in both populations. 33.3% of surgeons did not routinely recommend adenoidectomy before pharyngoplasty in either patient population [Table 5].

3.5. Self-reported complications and outcomes

A Likert scale for self-reported complications after pharyngoplasty was also included in the survey. Surgeons were asked to rate how often each potential complication occurred post-operatively using the following scale: *never, rarely, some of the time, often, almost always* [Table 6]. Neck pain was the most common complication reported by surgeons for both groups of patients, occurring *almost always* in 4.0% of 22q11.2DS patients and 4.8% of nonsyndromic patients. Delayed PO intake (greater than 24 h) in patients with 22q11.2DS was reported to occur *almost always* by 1.6% of surgeons, and *often* by 11.6%. Among nonsyndromic patients, fewer surgeons reported delayed PO intake *almost always* (0.8%) or *often* (7.1%). Postoperative sleep apnea was reported *rarely* in 22q11.2DS (46.8%) and in nonsyndromic patients (56.3%). Post-operative airway complications similarly were reported *rarely* in 22q11.2DS (54.8%) and nonsyndromic patients (64.3%).

Surgeons were also queried regarding revision rates after pharyngoplasty. For patients with 22q11.2DS, 43% of surgeons reported a revision rate of 0–5%, followed by 33% reporting a rate of 5–10%, 33% reporting 10–25%, 10% reporting 25–50%, 2% reporting 50–75%, and none reporting a rate of 75–100%. Overall, nonsyndromic patients had slightly lower reported revision rates with 60% reporting a 0–5% revision rate, followed by 49% for 5–10%, 11% for 10–25%, 2% for 25–50%, and none for rates of 50–75% and 75–100%. When surgeons were asked about their protocols, 54.8% reported that *my management decisions are very patient specific and often vary*, whereas 38.1% reported *I have an established protocol that I routinely follow*. 43.7% reported that *I feel I have reliable and reproducible results*, and 35.7% responded *I find patients with 22q11.2DS extremely challenging to manage*. 30.2% of surgeons replied *I would appreciate established guidelines for preoperative testing* and 8.7% felt *my results vary widely*.

4. Discussion

The management of VPD in patients with 22q11.2DS is complex and there is little current consensus on best practice. 126 surgeons who treat patients with clefts and patients with 22q11.2DS completed our survey, reporting on their current management algorithms, focusing on management of submucous cleft palate, pre-operative testing requirements, upper airway management before pharyngoplasty, and post-operative complications. In general, we found that providers managed patients with 22q11.2DS similarly to nonsyndromic patients, with three significant exceptions. Surgeons were more likely to perform SMCP repair alone as a first approach in nonsyndromic patients ($p = 0.031$) and posterior pharyngeal flap without SMCP repair in those with 22q11.2DS ($p = 0.017$). Surgeons were significantly less likely to use routine pre-op imaging of the velopharynx in nonsyndromic patients ($p = 0.016$). Overall, treatment protocols varied greatly from provider to provider.

Training and demographic data on surgeons treating VPD in 22q11.2DS is fairly diverse. Although the most common specialty was plastic surgery, 5 total specialties were represented, and about 4% of surgeons were trained in more than one specialty. In addition, 88.1% of surgeons completed a fellowship, and 36.9% of those completed multiple fellowships. Craniofacial surgery was the most common fellowship training completed, but a significant number completed pediatric ENT, pediatric plastic surgery, pediatric surgery, or multiple fellowships. The heterogeneous approaches to training may partly explain why treatment protocols varied so greatly.

Because not all patients with SMCP are symptomatic, surgical repair is traditionally delayed until speech emerges and VPD is demonstrated [22–24]. Our survey results are consistent with this practice showing the large majority of surgeons do wait for speech to emerge prior to surgical intervention for SMCP. However, 20.6% and 17.5% reported performing prophylactic repair of the SMCP during infancy in 22q11.2DS and nonsyndromic patients respectively, and an additional 2.4% and 1.6% reported performing SMCP combined with pharyngoplasty in infancy in 22q11.2DS and nonsyndromic patients respectively, suggesting that a sizeable minority of surgeons do intervene prior to speech development, especially among patients with 22q11.2DS [Table 2].

Reported speech outcomes after SMCP repair alone vary, but historically have been poor, resulting in high secondary surgery rates and leading to the practice of primary pharyngoplasty as well as simultaneous combined SMCP repair and pharyngoplasty [22,25–28]. Several more recent outcomes studies have linked preoperative velopharyngeal gap size and the anatomic severity of the submucous cleft to speech results, suggesting outcomes after SMCP may be predictable [25,26,29]. Regardless of these observations, many surgeons still advocate proceeding first with palate repair, with careful attention to muscle repositioning in all patients with SMCP, in the hope of avoiding the need for secondary surgery, or if needed, lessening the severity and thereby improving overall outcomes [29,30]. Others stress the importance of the degree and pattern of velopharyngeal closure and advocate proceeding directly to pharyngoplasty in patients with 22q11.2DS who have severe VPD and larger velopharyngeal gap sizes [13,31].

Our survey findings reflect these varied opinions and approaches to treatment with a wide variety of responses noted in Table 2. Comparison between responses for 22q11.2DS and nonsyndromic patients, however, did reveal some significant differences. Surgeons were more likely to perform SMCP repair alone as their first approach in nonsyndromic patients ($p = 0.031$) and posterior pharyngeal flap without

Table 6
Summary of self-reported Complications. Darker shades of green indicate high response, darker shades of red indicate low response or similar.

22q11.2DS					
Complication	*Never*	*Rarely*	*Some of the time*	*Often*	*Almost always*
Neck Pain	33.3%	19.0%	21.4%	19.8%	4.0%
Intraoperative bleeding	34.1%	50.8%	9.5%	0.8%	0.8%
Postoperative surgical side bleeding	42.1%	51.6%	1.6%	1.6%	0.0%
Postoperative surgical site infection	69.0%	27.8%	0.0%	0.0%	0.0%
Perioperative airway complications	26.2%	54.8%	14.3%	1.6%	0.0%
Postoperative sleep apnea	7.9%	46.8%	35.7%	6.3%	0.8%
Delayed PO intake (>24 hours)	5.6%	39.7%	38.9%	11.1%	1.6%
Hypocalcemia	74.6%	19.0%	0.0%	0.0%	0.0%
Readmission	38.9%	54.8%	3.2%	0.0%	0.0%
Difficulty clearing secretions	15.9%	42.9%	29.4%	7.1%	0.0%
Other	12.7%	1.6%	2.4%	0.0%	0.0%
Nonsyndromic Patients					
Complication	*Never*	*Rarely*	*Some of the time*	*Often*	*Almost always*
Neck Pain	32.5%	25.4%	19.8%	14.3%	4.8%
Intraoperative bleeding	31.0%	55.6%	7.9%	0.8%	0.8%
Postoperative surgical side bleeding	41.3%	53.2%	3.2%	0.8%	0.0%
Postoperative surgical site infection	65.9%	31.7%	0.0%	0.0%	0.0%
Perioperative airway complications	23.0%	64.3%	10.3%	0.8%	0.0%
Postoperative sleep apnea	5.6%	56.3%	30.2%	4.0%	0.8%
Delayed PO intake	7.1%	50.0%	33.3%	7.1%	0.8%
Hypocalcemia	84.1%	11.9%	0.0%	0.0%	0.0%
Readmission	38.1%	56.3%	0.8%	0.8%	0.0%
Difficulty clearing secretions	19.0%	49.2%	22.2%	5.6%	0.0%
Other	13.5%	3.2%	2.4%	0.0%	0.0%

SMCP repair in those with 22q11.2DS ($p = 0.017$). In addition, many surgeons indicated that they base their treatment decisions on severity (51.6% and 47.6%, for 22q11.2 and nonsyndromic patients, respectively) and also to a lesser degree on velopharyngeal imaging (23.8% on 20.6% for 22q11.2DS and nonsyndromic patients respectively), suggesting many surgeons individualize their surgical treatments in both populations. Speech evaluation prior to pharyngoplasty in patients with 22q11.2DS was required by the majority of surgeons (79.4%), whereas only about half (51.6%) of surgeons required velopharyngeal imaging of any kind [Table 4].

Given their complex medical comorbidities and overall higher risk of complications with surgery and anesthesia, careful pre-operative planning is important in this population to avoid unwanted complications. Potential medical comorbidities include congenital cardiac disease as well as endocrine abnormalities that can be exacerbated by the stress of surgery [32]. Reported anatomic abnormalities include medialization of the internal carotid arteries, potentially placing them into the surgical field, and therefore at risk for injury during pharyngoplasty [33,34]. Cervical spine anomalies, such as bony nonunion and multilevel fusion with the potential for cervical instability and spinal cord compression, particularly during extension of the head and neck, have also been described [35]. Cervical spine and carotid artery imaging studies and investigations are controversial, however, due to the increased costs and burden of care they confer on patients and their families, as well as ongoing questions as to their true necessity in performing safe and effective surgery [36,37]. One group (Witt et al., in 1998) questioned the value of pre-operative cervical vascular imaging, demonstrating no morbidity in the 10 patients (26%) that had detectable pulsations on preoperative nasoendoscopy. In their survey of cleft surgeons, half of the respondents altered their operative approach based on information obtained from angiographic studies [37]. Our survey results reflect this ongoing controversy regarding pre-operative studies prior to proceeding with pharyngoplasty in patients with 22q11.2DS – only half of respondents (50%) required preoperative cardiac evaluation, with even fewer requiring MRA imaging of the internal carotid arteries (29.4%), cervical spine radiographs (11.2%), and/or endocrine evaluation (6%) [Table 4].

In general, surgeons routinely asked about obstructive sleep apnea (OSA) symptoms, but use of a sleep questionnaire and/or sleep study was limited to patients reporting symptoms either pre- or post-operatively. Only a minority of surgeons routinely required pre-operative sleep studies in patients with 22q11.2DS, and fewer still required them post-operatively. 46.8% of surgeons reported that post-operative OSA occurred *rarely*, but that was followed by 35.7% responding that it occurred *sometimes*. OSA was also one of the three complications that any surgeons reported occurring *almost always*, the other two being neck pain and delayed oral intake. A 2014 study by Kennedy et al., found that 53% ($n = 39$) of patients with 22q11.2DS who were screened using a sleep study prior to pharyngeal surgery had OSA. 17 patients had a sleep study following VPD surgery for the indications of

sleep disordered breathing (n = 7) and routine post-surgical evaluation (n = 9), with 9 of these demonstrating OSA [20]. Given that many surgeons reported using sleep studies only if symptoms are present, it is unclear how many patients may have had OSA prior to surgery that was later uncovered with a sleep study. Overall practice patterns regarding screening for OSA pre-and post-operatively, as well as recommendations for pre-operative tonsillectomy and adenoidectomy varied as shown in Table 5, and no significant differences were seen between patient populations.

Though this study represents a much-needed exploration of practice patterns in a complex clinical population, there are some limitations. Survey studies such as this one are prone to researcher bias in the development of questions, poor match to the sample population, and response bias. In this study, the questions were developed by several clinicians, including a plastic surgeon, geneticist, speech pathologist, psychologist and specialty nurse practitioner, all of whom were part of a dedicated 22q11.2DS Center. To decrease bias, all questions and response options needed approval from all members of the team in order to be included. Regarding response bias, the surgical membership of the ACPA and SENTAC includes a high proportion of providers belonging to academic medical centers and established cleft-craniofacial teams, and may not represent the demographics of all providers caring for this patient population. In addition, although this survey included international members of these organizations, the majority of respondents practice in the US, and thus the findings primarily reflect practice patterns within the US. Only 126 surgeons left viable surveys, further narrowing the potential generalizability of these responses, with an unknown number receiving the surveys in order to maintain privacy. In addition, complication and revision rate data are self-reported, which may or may not correlate well with actual hospital-based data. Despite these limitations, this survey presents some important findings about current approaches to treating VPD. Further research is needed to examine how specialty, location, and presence of the dedicated 22q11.2DS center may affect practice patterns. It is hoped that this would lead to future refinement and standardization of medical treatment for this patient population.

5. Conclusion

In summary, practice patterns for the management of VPD in patients with 22q11.2DS vary across providers and more research is required to determine the significance of these differences. Further collaborative studies are needed to address these and other variables in order to develop optimal treatment paradigms for VPD in patients with 22q11.2 DS.

Conflicts of interest

No conflicts of interest to disclose.

Financial disclosures

Donna M. McDonald-McGinn, MS, LCGC has presented lectures on 22q11.2DS for Natera.

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