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ORIGINAL ARTICLE

Orofacial dysfunction in ectodermal dysplasias measured using the Nordic Orofacial Test-Screening protocol

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Abstract

Objective. To screen orofacial function in people with various ectodermal dysplasia (ED) syndromes and compare with a healthy reference sample. ***Material and methods.*** The ED group comprised 46 individuals (30 M and 16 F; mean age 14.5 years, range 3–55). Thirty-two had hypohidrotic ED, while 14 had other ED syndromes. The reference sample comprised 52 healthy individuals (22 M and 30 F; mean age 24.9 years, range 3–55). Orofacial function was screened using the Nordic Orofacial Test-Screening (NOT-S) protocol containing 12 orofacial function domains (maximum score 12 points). ***Results.*** The total NOT-S score was higher in the ED group than in the healthy group (mean 3.5 vs. 0.4; $p < 0.001$). The dysfunctions most frequently recorded in the subjects with ED occurred in the domains chewing and swallowing (82.6%), dryness of the mouth (45.7%), and speech (43.5%). Those with other ED syndromes scored non-significantly higher than those with hypohidrotic ED (mean 4.6 vs. 3.0; $p > 0.05$). ***Conclusions.*** Individuals with ED scored higher than a healthy reference sample in all NOT-S domains, especially in the chewing and swallowing, dryness of the mouth, and speech domains. Orofacial function areas and treatment and training outcomes need to be more closely evaluated and monitored.

Key Words: *NOT-S, orofacial function, rare disorders, syndromes*

Introduction

Orofacial function involves several vital and social functions, the mouth being central especially for chewing, swallowing, and speech, which are dependent on salivation and dentition. In the oral cavity, saliva lubricates the hard and soft tissues. Lack of saliva impairs clarity of speech, chewing and swallowing [1], taste [2], and voice quality [3]. The complexity of these oral functions means that clinical professionals such as dentists, gastroenterologists, ENT specialists, phoniatricians or laryngologists, and speech and language pathologists are needed to address oral problems. Despite considerable effort toward establishing common criteria for assessing orofacial function, no widely used, comprehensive instrument has been available. This was the incentive to develop a comprehensive screening instrument for evaluating orofacial function, i.e. the Nordic Orofacial Test-Screening protocol (NOT-S) [4]. The test has been shown to satisfactorily identify areas (domains) of impaired orofacial function, discriminate between individuals with various degrees of disability and healthy subjects, and to have good inter- and intra-examiner reliability.

Ectodermal dysplasia (ED) syndromes comprise a group of hereditary disorders that are clinically and genetically heterogeneous and characterized by abnormal development of tissues of ectodermal origin [5]. Currently, out of approximately 200 different ED syndromes, a causative gene has been identified in only about 30 [6], and the diagnosis is therefore based on clinical signs and symptoms in a majority of cases. The most common type of ED is hypohidrotic ED, which affects the hair, teeth, and sweat glands [7]. The gene for x-linked hypohidrotic ED – *EDA* – was identified by Kere et al. in 1996 [8].

Hypohidrotic ED has different modes of inheritance: x-linked, autosomal dominant, and autosomal recessive [9]. Oligodontia in the primary and permanent dentitions is a frequent feature in ED and in

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a recent Danish study of 23 genetically characterized males with x-linked hypohidrotic ED a mean of 22 (range 14–28) missing permanent teeth was reported [10]. Impaired salivation is another common clinical sign [11].

In ankyloblepharon-ectodermal defects-cleft lip/palate syndrome, ectrodactyly-ectodermal dysplasia-cleft lip/palate syndrome, and Rapp Hodgkin syndrome, clefts of the lip, the palate or both are characteristic, but not required for diagnosis. Tongue function, which is crucial for orofacial function, is not known to be impaired in ED, but oral clefts, missing teeth, and dryness of the mouth may compromise sucking, chewing, swallowing, and speech. Orofacial function in individuals with ED has not been studied systematically, however.

The aim of our study was to screen orofacial function in individuals with various ED syndromes and to compare the results with data from a reference sample of healthy people. The null hypothesis was that there was no difference between affected and non-affected individuals.

Material and methods

Individuals diagnosed with an ED syndrome (aged 3 years or older) who attended family conferences arranged by the National Foundation for Ectodermal Dysplasias (NFED, the North American support group) and the Swedish ED Society were invited. Participation was voluntary and all Swedish and 70% of United States individuals accepted. They all had obvious signs and symptoms of ED. An informed-consent form was signed by each participant or a parent. The ED group comprised 46 individuals (30 M and 16 F; mean age 14.5 years; range 3–55, median 10), i.e. 31 from the U.S. and 15 from Sweden. ED diagnoses were self-reported by study participants or parents. Thirty-two had hypohidrotic ED, 30 with x-linked and 2 with autosomal-dominant inheritance. Fourteen (4 M and 10 F) had other ED syndromes. Three females with severe signs and symptoms did not have a specific ED diagnosis and are referred to as "ED unspecified" within the group "Other ED syndromes". A reference sample of 60 healthy individuals was drawn from the original study [4]. Eight older than 55 were excluded and the remaining 52 healthy individuals made up the reference sample (22 M and 30 F; mean age 24.9 years; range 3–55, median 20). There were 36 (78.3%) children and adolescents aged 3–20 in the ED group versus 26 (50.0%) in the reference sample. The ED group comprised 65.2% males versus 38.5% in the reference sample (Table I).

Screening of orofacial function

Two calibrated examiners screened orofacial function using the NOT-S protocol, originally developed and tested in Swedish and later translated to English through back-translation to control for identical content and linguistic quality [4]. The protocol contains 12 domains of orofacial function – six assessed through interview and six through clinical observation as the participant performs various tasks using a picture manual. The six interview domains are: (I) sensory function, (II) breathing, (III) habits, (IV) chewing and swallowing, (V) drooling, and (VI) dryness of the mouth. The six domains assessed in the clinical examination are: (1) the face at rest, and tasks regarding (2) nose breathing, (3) facial expression, (4) masticatory muscle and jaw function, (5) oral motor function, and (6) speech. A positive answer in a domain gets 1 point, the maximum score being 12 points. For young children, the parents answered the questions in the interview. In the ED group, two additional symptoms related to voice and speech were evaluated: hoarseness and lisping. All examinations were done with removable dental prostheses in place.

Table I. Distribution of self-reported ectodermal dysplasia (ED) diagnoses according to country and gender for individuals undergoing Nordic Orofacial Test-Screening (NOT-S).

	No. of individuals				
Self-reported diagnosis	US	Sweden	Male	Female	Total
Hypohidrotic ED					
X-linked	20	10	25	5	30
Autosomal dominant	0	2	1	1	2
Other ED syndromes					
EEC* syndrome	4	0	2	2	4
EEC syndrome without clefting	1	0	1	0	1
Hay-Wells syndrome	1	0	1	0	1
Goltz syndrome	1	0	0	1	1
Witkop syndrome	1	0	0	1	1
Rapp-Hodgkin syndrome	0	3	0	3	3
Unspecified ED syndrome	3	0	0	3	3
Total	31	15	30	16	46

*Ectrodactyly Ectodermal Dysplasia Cleft lip/palate.

Table II. NOT-S results in relation to age in 46 individuals with ED and a reference sample of 52 healthy individuals.

Age groups (years)	No. of individuals						Total NOT-S score (mean)	
	ED group			Reference sample			ED group	Reference sample
	Male	Female	All	Male	Female	All	All	All
3–6	10	5	15	4	5	9	4.1	0.7
7–10	9	3	12	5	7	12	3.3	0.2
11–20	6	3	9	4	1	5	2.7	0.2
21–55	5	5	10	7	19	26	3.7	0.4
Total	30	16	46	20	32	52	3.5	0.4

Statistical analyses

Data were analysed with the Statistical Package for the Social Sciences (SPSS; v. 14.5, SPSS Inc., Chicago, Ill., USA). Categorical data were analysed using the chi-square test. The level of significance was set at $p < 0.05$.

Results

Mean total NOT-S score was 3.5 (range 0–8) in the ED group and 0.4 in the reference sample (range 0–2). The difference was statistically significant ($p < 0.001$). Males in the ED group had slightly higher scores compared to females, but the difference was not statistically significant ($p > 0.05$).

Table II gives mean total NOT-S scores for subgroups related to age in the study group and the reference sample. Mean scores for individuals with ED varied from 2.7 to 4.1 and in the reference sample from 0.2 to 0.7. In 3 to 6-year-olds, the highest scores occurred in both the ED group and the reference sample.

Dichotomization of the ED group was based on ED diagnosis into one group of 32 individuals with hypohidrotic ED and one group of 14 comprising all other ED syndromes. Mean total NOT-S score for the hypohidrotic ED group was 3.0 (range 0–6) and for other ED syndromes 4.6 (range 1–8), but the difference was not statistically significant ($p > 0.05$).

Mean scores for the NOT-S interview, the NOT-S examination and total NOT-S scores for the ED group and the reference sample are listed in Table III. Both ED groups scored higher on the interview and the clinical examination than the reference sample.

Out of 14 individuals with ED who had the highest total NOT-S scores (range 5–8), 5 had hypohidrotic ED while 9 (64.3%) had other ED syndromes. Of these, 4 with EEC syndrome and 1 with Rapp-Hodgkin syndrome had clefts, and 2 had an undiagnosed ED syndrome with severe oral signs and symptoms.

Results for the NOT-S domains and for symptoms of hoarseness and lisping in individuals with ED are given in Table IV. The dysfunctions most frequently recorded in the ED group occurred in the chewing and swallowing (82.6%) and dryness of the mouth (45.7%) domains of the NOT-S interview and in the speech (43.5%) domain of the NOT-S examination. In some individuals with ED, dysfunctions were found in all domains of the NOT-S.

Fifteen, i.e. 13 with hypohidrotic ED and 2 with other ED syndromes, had a hoarse voice (32.6%). Twenty-two, i.e. 14 with hypohidrotic ED and 8 with other ED syndromes, had a lisp (47.8%). These symptoms were not evaluated in the reference sample.

Discussion

Dentition and salivation are important for orofacial function, and the prevalence of oral symptoms is high in many ED syndromes, but like most other signs and symptoms in ED, oral symptoms vary widely in clinical expression. Thus tooth agenesis may vary

Table III. Distribution of Nordic Orofacial Test-Screening (NOT-S) results for orofacial function in 46 individuals with ectodermal dysplasia (ED) and a reference sample of 52 healthy individuals.

	No. and gender of examined individuals			NOT-S interview scores		NOT-S examination scores		Total NOT-S scores	
	Male	Female	All	Mean	Range	Mean	Range	Mean	Range
Hypohidrotic ED	26	6	32	2.0	0–5	1.0	0–3	3.0 n.s.	0–6
Other ED syndromes	5	9	14	2.6	0–5	2.0	0–6	4.6	1–8
All ED syndromes	31	15	46	2.2	0–5	1.3	0–6	3.5***	0–8
Reference sample	20	32	52	0.3	0–2	0.1	0–1	0.4	0–2

Chi-square test. *** $p < 0.001$; n.s. $p > 0.05$.

Table IV. Scores per domain of the Nordic Orofacial Test-Screening (NOT-S) in 46 individuals with ED and a reference sample of 52 healthy individuals.

		Hypohidrotic ED ($n=32$)		Other ED syndromes ($n=14$)		Total ED group ($n=46$)		Reference sample ($n=52$)	
Domain		*n*	%	*n*	%	*n*	%	*n*	%
NOT-S interview									
I	Sensory function	7	21.9	5	35.7	12	26.1	1	1.9
II	Breathing	4	12.5	7	50.0	11	23.9	6	11.5
III	Habits	11	34.4	3	21.4	14	30.4	5	9.6
IV	Chewing and swallowing	26	81.3	12	85.7	38	82.6	2	3.8
V	Drooling	3	9.4	3	21.4	6	13.0	0	0.0
VI	Dry mouth	14	43.8	7	50.0	21	45.7	0	0.0
NOT-S examination									
1	Face at rest	7	21.9	5	35.7	12	26.1	4	7.7
2	Nose breathing	1	3.1	1	7.1	2	4.3	0	0.0
3	Facial expression	1	3.1	4	28.6	5	10.9	0	0.0
4	Masticatory muscle and jaw function	5	15.6	5	35.7	10	21.7	0	0.0
5	Oral motor function	6	18.8	4	28.6	10	21.7	1	1.9
6	Speech	11	34.4	9	64.2	20	43.5	1	1.9
Added symptoms									
	Hoarseness	13	40.6	2	14.3	15	32.6		
	Lisping	14	43.8	8	57.1	22	47.8		

from agenesis of a few teeth to anodontia and affect development of the jaws and the alveolar processes [12]. Low whole saliva flow rates have been reported in oligodontia [13,14] and in hypohidrotic ED [11]. In addition, agenesis of major salivary glands has been reported in hypohidrotic ED [15]. Even although oral signs and symptoms are well recognized, no comprehensive evaluation of orofacial function in individuals with ED has been presented.

A general difficulty in studies of rare disorders is in including a sufficient number of affected individuals, which has implications for power and level of evidence [16]. This study screened orofacial function in individuals with various ED syndromes gathered at family conferences in the U.S. and Sweden. The ED diagnoses were self-reported by the participant or a parent. The situation is similar between the U.S. and Sweden in that the diagnosis is commonly based on clinical examination. Out of 5,760 individuals with ED registered in the NFED database, only one-third have a genetically verified diagnosis, and still a causative gene has been identified in only about 15% of described ED syndromes [6]. In the case of young children, the parents were asked to answer the questions in the interview domains, which was also the case in the reference sample. Screening occurred in the native language of the individuals with ED and was conducted in non-clinical settings. Many of the examined individuals with ED had received extensive prosthetic rehabilitation. But this study comprised orofacial screening only; present clinical oral situation and performed treatment were not recorded. They were compared with a previously reported reference sample even though the ED group was younger and included more men than the reference sample.

The ED group had significantly higher total NOT-S scores than the reference sample, and when analysed according to age group this overall difference persisted. The higher mean age of the reference sample thus had no important impact on the outcome, and the null hypothesis could be rejected.

The mean total NOT-S scores for the ED group were higher in the interview than in the examination, and were higher than in the reference sample in both parts of the test. Among the 14 individuals with ED who scored highest in NOT-S, nearly two out of three belonged to the group with other ED syndromes, which reflects the complexity of symptoms in this subgroup. The interview domains in which the ED group scored most frequently were chewing and swallowing, which is probably related to the reduced number of teeth and dryness of the mouth. Dryness of the mouth was reported by nearly half of the ED group, and 43.5% received a score in the speech domain. Dysfunction was registered in all 12 domains of the NOT-S in the ED group, which indicates that a wide range of orofacial functions may be affected. The added evaluations of voice clarity and speech indicated a high prevalence in individuals with ED. One-third had a hoarse voice, and most of them had hypohidrotic ED. This symptom may be caused by dryness of the larynx due to low salivary secretion and a low number of mucus-producing glands in the aerodigestive tract [17]. Almost half had a lisp, a symptom reported to occur in 3–10% of school-age children [18].

Within the limitations of a screening of orofacial function, the results clearly indicate a need for multi-professional cooperation among speech and language pathologists, ENT-specialists, phoniatricians, and specialists in different disciplines of

dentistry, in the monitoring and clinical management of orofacial dysfunction in individuals with ED during the formative years. Further studies are needed to elucidate the underlying causes of impaired orofacial function in ED syndromes. The NOT-S can be a useful tool indicating areas for further examination and referral, and for studies to establish orofacial dysfunction and evaluate results of treatment and training. Establishment of oral dysfunction patterns and monitoring of intervention and treatment outcomes in central registries could more clearly define the special oral needs in individuals with ED and other rare disorders.

Conclusions

Individuals with ED scored higher than a healthy reference sample in all NOT-S domains, especially the domains of chewing and swallowing, dryness of the mouth, and speech. A score in any NOT-S domain should be an indicator for further specific examinations or referrals.

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