Potential Impact of Mild to Moderate Conductive Hearing Loss on Speech in the Cleft Palate Population

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CEN for Cleft Palate and Craniofacial Anomalies (National)

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Speech with mild fluctuating conductive hearing loss v. moderate to profound hearing loss.

- 1528 speech or language delayed, children (MA 4;9 yrs)
- 3 groups
  - (I) constant normal hearing,
  - (II) mild fluctuating conductive hearing loss
  - (III) bilateral moderate to profound sensorineural hearing loss requiring hearing aids
- Conclusions
  - mild loss affected speech and language development early diagnosis
  - Important for mild-moderate hearing loss to be diagnosed early
  

90-95% children with cleft palate OME- (Goudy 2006)
80% => conductive hearing loss (Flynn et al 2009)

- Impact of cleft palate on speech and expressive language
  - combined impact of both structural and perceptual problems in first year of life


Psycholinguistic model (Stackhouse and Wells)

Lexicon

Language Store

1. Speech mechanism:
2. Cleft type
3. Surgical regime
4. VP function articulatory constraints

Input

Peripheral Auditory Processing

Output
Psycholinguistic model (Stackhouse and Wells)

Management Mild – moderate loss
- Grommets - +ve effect (Goudy et al 2006) but with variable duration and variable tolerance
- Hearing aid - +ve effect with variable tolerance
- Watchful waiting - -ve effect of variable hearing

Impact of mild / moderate hearing loss on speech perception
- Low frequency loss affects perception of vowels and voiced consonants
- High frequency loss affects perception of high frequency fricatives
- Low-mid frequency loss 30 dB could lead to a loss of 30% of speech information specifically vowels and voiced consonants/approximants (Dodd 1989)
- Specific types of loss - Florida Resource Guide

Influences on speech perception - listening environment
- Noise
  - Ambient noise affects perception of intensity
  - Location of ambient noise
- Reverberation
  - Degrades the quality of perceived incoming sound - audiograms do not take account of this variable
- Proximity of sound source
  - Sound quality deteriorates with distance
- Speakers internal breathing noise affects perception of others speech and of own speech up to 60dB

INSERT Noisy breather video

Behavioural signs of conductive loss
- Signs of hearing loss:
  - Child may become irritable,
  - Disturbed sleep
  - Unresponsive to verbal direction
  - Vacant facial expression
  - Slow reactions
Impact of conductive hearing loss in first year

- 1st year: auditory pathways develop = listening skills
- Awareness of the acoustic characteristics of native language
- Intonation patterns
- ‘Legal’ sound combinations and word patterns in native language
- Infant single word lip reading at 19 months: multi-channel speech processing (Dodd 1989)
- Most salient signals for an infant with hearing loss = visual and tactile – not auditory

Psycholinguistic model [Stackhouse and Wells]

Developing LEXICON
Limited phonetic, phonological & language store

INPUT
OUTPUT
1. Speech mechanism:
2. Cleft type
3. Surgical regime
4. VP function
Articulatory constraints

Relationship between palate function for speech and Eustachian tube function for hearing

Muscles that elevate the palate also contribute to middle ear ventilation
- Tensor palatini opens Eustachian tube
- Levator Palatini maintains the opening

Case examples

Case 1 FT Unrepaired SMCP Glottal, pharyngeal and nasal fricatives – classic signs of possible VPD

- Add VFI

Case 1 FT At first speech assessment

1. Nasal tone
2. Non-oral pattern: glottal/pharyngeal articulation and nasal fricatives
3. Suspected Hearing loss – referred for hearing assessment
4. Suspected VPD referred to Cleft Clinic

<table>
<thead>
<tr>
<th>Labial</th>
<th>Alveolar</th>
<th>PostAlv</th>
<th>Velar</th>
<th>Gl</th>
<th>Bl</th>
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Case 1 Hearing Test between 1st and 2nd Speech assessment – subsequent diagnosis of submucous cleft palate

Case 1 Palate Investigation assessment 1 month after fitting hearing aids

Hearing assessment – bilateral 40-50 dB hearing loss
Diagnosed submucous cleft palate

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<td>n t d s</td>
<td>z j g</td>
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<td>z j g</td>
<td>k g</td>
<td>h g</td>
</tr>
<tr>
<td>SFW</td>
<td>f v n t d</td>
<td>z j g</td>
<td>k g</td>
<td></td>
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</tbody>
</table>

After hearing aids fitted – residual pharyngeal ‘s’

/b t/ + following vowel - palate is raised

Palate is lowered for pharyngeal /t/ and remains lowered for following vowel

What type of VPD - mislearning?

Case 2 TK Unusual Vowels and backing

Bilateral cleft palate + hearing loss
- 35 dB loss pre-palate repair grommets recommended but parents declined –
- [m n ġ ā] unusual vowels ‘or’ = [œ]
- 2:2 yrs Hearing aids fitted

Case 3 DJ Nasal realization of plosives and fricatives – classic signs of VPD

Bilateral cleft lip and palate + hearing loss – recently fitted with hearing aids

[n] for /t d k g f s z j g dʒ/ + /ʃ ʧ ʤ /

New [b] indicates potential for VP function for speech
Case 3 DJ sample audiograms 2013-2014

Case 3 MT Syllabic nasals – replacing vowels with nasal consonants
Cleft soft palate, 35 dB loss pre-palate repair, ear canal too narrow for grommets until 3.9yr

Velar nasal stops oral airstream – exclusively nasal production

Phonetic inventory ‘m n ̍’ and syllabic nasals for strings or words [ɯ̍]

MT: Serial Audiograms following grommet extrusion

Hypernasal resonance [α ɪ ̽] – non-cleft VPD
No reason for vowels to not be pronounced

ADD JODIE + VFL

Differential diagnosis – Nasalised vowel versus nasal realization/replacement of vowel
- newly identified risk of misdiagnosis
  - ‘fish’ [fʊ̍]; dolly [ʤɪfʊ̍]
  - ‘I go in the water’ [bɪ ɡʊ̍ ɪŋ ɡwɜ̍]
  - Syllabic nasal replaces /ɪ/; vowels in weak syllables; whole words in utterance string

Add Ben T less obvious eg syllabic nasal; weak syllable, high vowel
Speech perception: Acoustic signal - harmonics/formants

- F1 250 - 1000 Hz determined by vertical tongue height
- Vowels 'ee' and 'oo' share the same 1st formant with /n/ so can be confused with nasal i.e. [i u] sounds like [n ɲ]
- F2 1000 - 2000 Hz - antero-posterior tongue position affects resonance of the voice
- Vowels 'ee' and 'oo' have high F2 values which may not be perceptible with low-mid frequency loss

Case 5 Syllabic nasals: NO palatal deficiency - history of conductive hearing loss

- Therapy has corrected consonants! [s. nd]
- Nasal realization of vowels not previously diagnosed
- Perceptual confusion between [i] [u] and 'n ng' similar F1 formant: VP mislearning?

Speech characteristics in children with a functional VP sphincter

<table>
<thead>
<tr>
<th>Cases</th>
<th>Cleft Palate /SMCP</th>
<th>Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case 1 Unrepaired SMCP + 40-50 dB HL</td>
<td>Pharyngeal + Nasal fricatives</td>
<td>HA + rapid speech changes</td>
</tr>
<tr>
<td>Case 2 TK Repaired BCLP</td>
<td>Vowel distortions Backing /t/=/[k]</td>
<td>HA + therapy</td>
</tr>
<tr>
<td>Case 3 DJ Repaired BCLP</td>
<td>Nasal realizations For plosives &amp; Fricatives</td>
<td>HA + rapid speech changes</td>
</tr>
<tr>
<td>Case 4 MT Repaired Palate</td>
<td>Nasal replacement of whole syllables</td>
<td>Grommets - steady changes in vowels</td>
</tr>
<tr>
<td>Case 5 AM Referred as Susp VPD</td>
<td>Nasal replaces long Vowels and whole words</td>
<td>History of conductive hearing loss/Therapy focussed on vowels</td>
</tr>
</tbody>
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Speech characteristics associated with hearing loss

The phonological abilities of hearing impaired children: Interim results from the LOCHI study

<table>
<thead>
<tr>
<th>Features reported in 3 or more Hearing Impairment studies</th>
<th>LOCHI study</th>
<th>Specific to Cleft Speech</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cluster reduction</td>
<td>80%</td>
<td>Yes</td>
</tr>
<tr>
<td>Final consonant deletion</td>
<td>32%</td>
<td>Yes</td>
</tr>
<tr>
<td>Stopping</td>
<td>58%</td>
<td></td>
</tr>
<tr>
<td>Assimilation</td>
<td>9%</td>
<td></td>
</tr>
<tr>
<td>Initial consonant deletion</td>
<td>3%</td>
<td></td>
</tr>
<tr>
<td>Gliding of liquids</td>
<td>62%</td>
<td></td>
</tr>
<tr>
<td>Glottal replacement</td>
<td>0%</td>
<td>Yes</td>
</tr>
<tr>
<td>Palatal fronting</td>
<td>3%</td>
<td></td>
</tr>
<tr>
<td>Velar fronting</td>
<td>19%</td>
<td></td>
</tr>
</tbody>
</table>

New findings in LOCHI study

| Weak syllable Deletion                                    | 49%         |                         |
| Voicing                                                   | 42%         |                         |
| Backing                                                   | 26%         | Yes                      |
| Frication                                                  | 7%          |                         |
| ?? Vowel distortion                                       | ?           | ?                        |

Conductive Hearing loss related phonological consequences

- Systematic simplifications
  - No distinction between voiced /voiceless targets
  - Gliding fricatives /z s /J/ => [j]
  - Spirantization /=s/ => [s] [especially word medial]‘sissing on a bus’
  - Vowel distortion /i u/ => [e a] or nasal replacing vowel /i u/ => [m n ɲ] ‘syllabic nasal’
  - /m n conflation /nou/ => [mou ]

- Word/syllable structural simplifications
  - Final consonant deletion [/θ]
  - Weak syllable deletion
  - Grammatical ‘s’ omission
  - Absent tense markers

Infant Intervention

Word/syllable Deletion

40 minutes
Advice to Parents: about their baby...

- From birth infants analysing the sounds and appearance of native language *no time to waste/*watchful waiting* ....*  
- Listening environment is within parental control — nearly as effective as grommets  
- Child will hear some of what parents say  
- But may not hear well — comprehension through vowel analysis — may not hear all the sounds in word

Management options

1. Grommets  
2. Hearing aids  
3. Watchful waiting?  

> AND  
1. Active communication strategies: focused stimulation to develop adaptive strategies and ensure that the period of watchful waiting is not dead time

Take home messages

- Middle Ear History (Sheahan 2002) 0 — 2 is more relevant than hearing status at time of assessment  
- Nasal realizations may be hearing related — *risk of misdiagnosis of VPD*  
- Nasalised vowels may be nasal replacement of vowels — syllabic nasals — *risk of misdiagnosis of VPD*  
- Cleft specialist SLTs may need to engage more in management of perceptual deficiency — consider using visual, tactile, orthographic presentation to supplement variable auditory signal

Suggestions for early input with diagnosed or suspected mild moderate hearing impairment

1. Phrases with distinctive prosody: *look at that, it’s too heavy, mmmm, that’s good, no don’t touch, wait a minute....*  
2. Eye contact — elicit visual attention, good light on speakers face  
3. Repetitive language  
4. Bilabials *‘bye bye, pop the bubbles....’*  
5. Animal sounds: *vowels ‘moo, meow, baa, oo-oo...’*  
6. Tactile input: Feeling the airstream on hand or face  

> These recommendations are similar to advice given to stimulate articulatory exploration with cleft palate

Advice to all parents: what to do......

- Use a quiet voice: increases the relative volume of the consonants & develops listening to quiet sounds  
- Use key phrases repetitively  
- Babies like *‘motherese’*  
- Simple repetitive commentary with activities  
- Short phrases  
- Proximity of sound source  
- Avoid over articulation or increased volume  
- Input ++ but little or no pressure to ‘produce’
Key references


References