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The Influence of Occlusal Class in the Production of Voiceless Fricatives

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Introduction

- The aim of this study was to relate the production of voiceless fricatives with the type of dental occlusion.
- The articulatory gestures during the production of consonant sounds such as the voiceless fricatives **/f/**, **/s/** and **/ʃ/**, seem to be disturbed for type II class (Angle's classification) individuals, which frequently require the training of compensatory articulation to get a "normal" acoustic output.
- This work is central to the first two authors' clinical practice in Speech and Language Therapy in which it is frequent the need to treat articulatory disorders.

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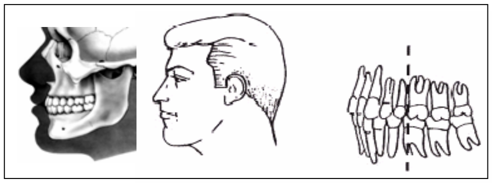
Introduction

- Angle’s (1907) classification of malocclusion :
  - **Class I** - A malocclusion in which the mesiobuccal cusp of the maxillary first molar occludes in the buccal groove of the mandibular molar - **Normal Occlusion**.



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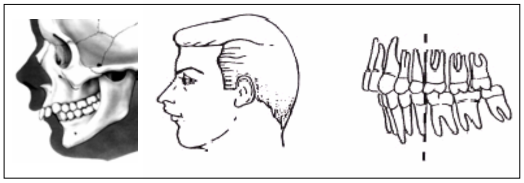
Introduction

- Angle’s (1907) classification of malocclusion:
  - **Class II** - A distal (posterior) placement of the mandibular (lower) molar, mesial (anterior) relationship of the maxillary (upper), or a combination of the two.



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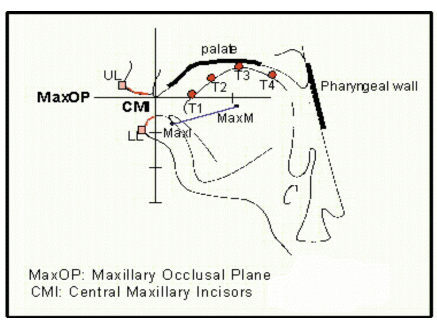
Literature Review

- The relationship between acoustic cues and articulatory movement has been widely studied using the XRMB-SPD (Westbury, Hashi and Lindstrom, 1998; Hashi, Honda and Westbury, 2003).
- The coordinates of the pellets available from the XRMB-SPD have been recently used as input to articulatory models (Blachburn and Young 2001; Kirchhoff, Fink and Gerhard 2002).
- Tasko and Westburry (2004) studied the relationship between articulator speed and trajectory curvature for speech-related mid-sagittal planar movements of the tongue, lower lip and mandible in a group of speakers from the XRMB-SPD.

Method

- We used the **X-ray Microbeam Speech Production Database** (**XRMB-SPD**) developed at the University of Wisconsin (Westbury 1994).
- Pellets' position:
  - Lips
    - **UL** – Upper Lip
    - **LL** – Lower Lip
  - Mandible
    - **MaxI** – Central incisors
    - **MaxM** – 1st/2nd molar
  - Tongue
    - **T1** – Ventral
    - **T2** – Mid-ventral
    - **T3** – Mid-dorsal
    - **T4** – Dorsal



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Method

- The selected corpus for this study was composed of fricatives **/f/**, **/s/** and **/ʃ/**, produced in nonsense words in a stressed syllable.
- We used the nonsense words **/ɐˈfa/**, **/ɐˈsa/** and **/ɐˈʃa/** from task 16 (citation VCV's), which were examples phonotactically possible in European Portuguese.
- We chose these examples because we wanted to relate the results with our clinical practice in Portugal.

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Method

- There were **14 male** individuals registered in the database with **normal occlusal class**, according to Angle's classification (Morris 2004, pp. 162, 166; Westbury 1994, p. 24), who could be used to observe the "normal" articulatory gestures in fricative sounds.
- From this group of individuals we only used 4 subjects because some of the other speaker's records were missing task 16.

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Method

- The "**normal**" subjects were 20, 21, 22 and 26 years old (**JW41**, **JW45**, **JW15** and **JW55**).
- We also selected a 20 year old male with **type II** class for comparison (**JW61**).

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Method

- We analysed the anatomical structures involved in articulation and the articulatory gestures of all the subjects, and studied the **distance** of the tongue pellets to the palate and **duration** of each fricative production.
- We used the TF32 and XYD programs by Paul Milenkovic to analyse and import the data into Excel and MatLab.
- We then calculated the distance from each tongue pellet to the palate and plotted the data for further analysis.

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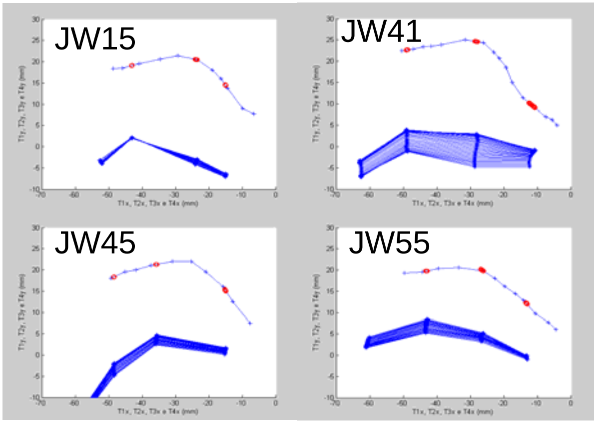
Results

- Production of ***/f/*** - Normal Class



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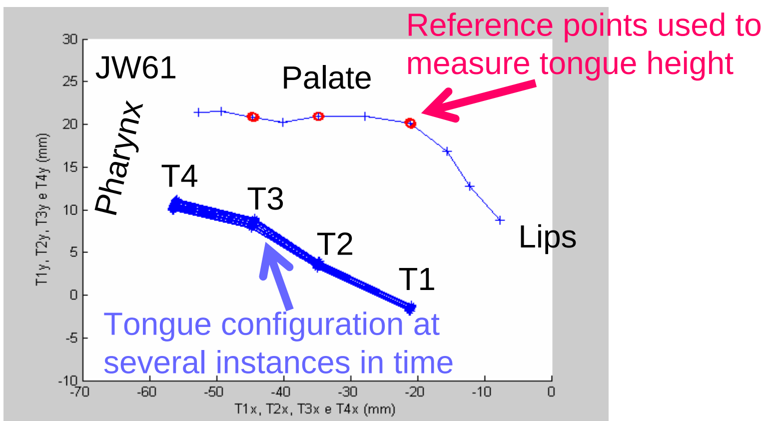
Results

- Production of ***/f/*** - Type II Class



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Results

- The type II class individual had a retracted lower lip (relative to the upper lip), a tipped pharynx (relative to the vertical plane) and a horizontal posture of the tongue (a compensatory posture), when compared to the normal class speakers.

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Results

- The observed differences of tongue posture during the production of **/f/**, are due to the fact that there is no cavity in front of the constriction, and most of the noise is generated between the front teeth and the lips (Stevens 1998, pp. 389, 411).

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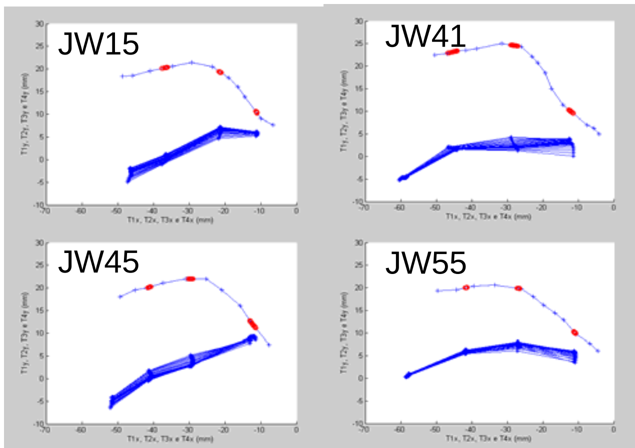
Results

- Production of ***/s/*** - Normal Class



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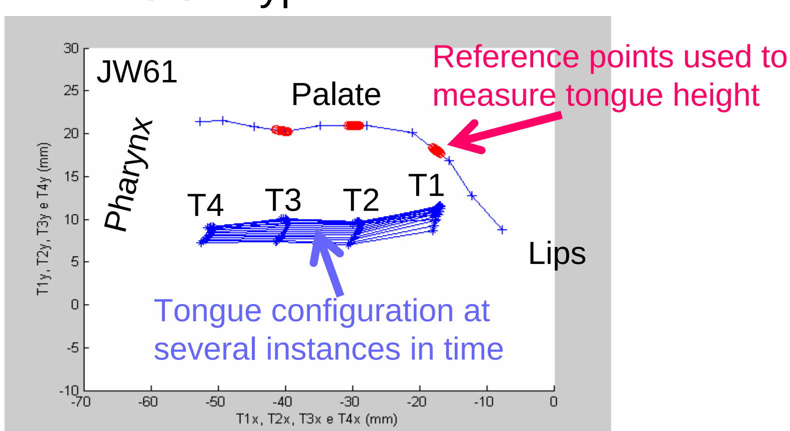
Results

- Production of ***/s/*** - Type II Class



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Results

- The production of */s/* by normal class individuals was characterised by a constriction around the first tongue pellet located approximately 12mm after the reference pellet (the maxillary incisors).

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Results

- The production of */ʃ/* for the normal class group has the minimal constriction around 15mm (relative to the same reference pellet).
- The type II class individual produced */s/* and */ʃ/* more posteriorely than the normal class speakers (*/s/* – 15mm; */ʃ/* – 20mm).

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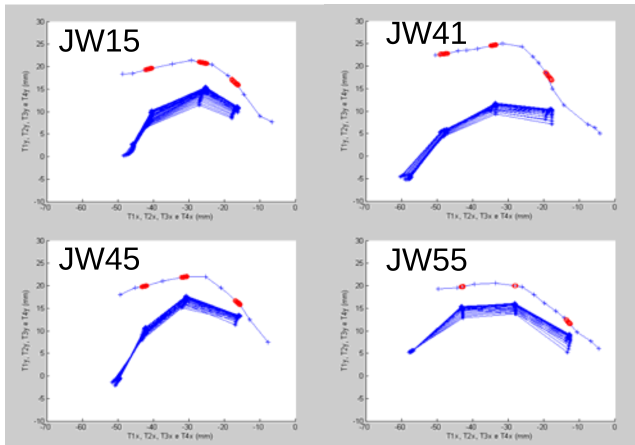
Results

- Production of */ʃ/* - Normal Class



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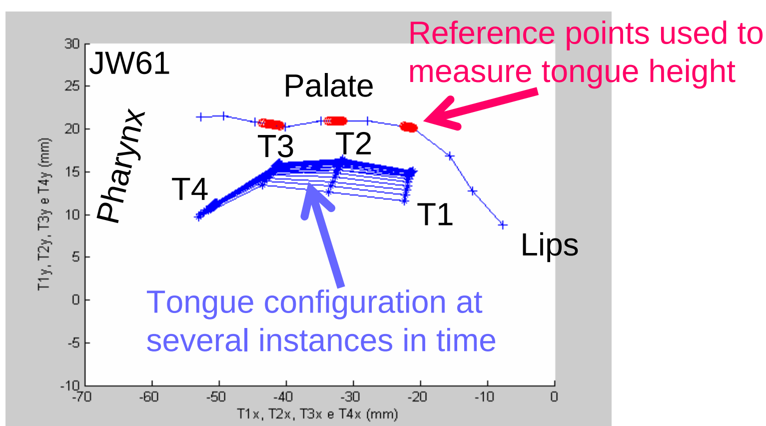
Results

- Production of */ʃ/* - Type II Class



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Results

- Normal (mean values of 4 subjects) and Type II distance of the tongue pellets to the palate (P1-Pal, P2-Pal and P3-Pal) for each fricative.

Fricative	Occlusal Class	P1-Pal (mm)	P2-Pal (mm)	P3-Pal (mm)	Duration (ms)
/f/	Normal	15	20	18	156
	Type II	22	18	13	131
/s/	Normal	5	17	19	204
	Type II	7	12	11	110
/ʃ/	Normal	5	7	11	182
	Type II	5	5	5	151

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Results

- During the production of */s/* by the type II class speaker, P1 was lower than for the normal class individuals.
- In contrast, P2 and P3 pellets were higher for the type II class subject.
- The major differences between the two classes were related to the height of P3 and P4, that were raised in all productions by the type II class subject in relation to the normal class group.
- This may be related to the described compensatory posture of the pharynx that could have interactions with the tongue base muscles.

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Results

- We also calculated the difference between the place of minimal constriction for P1 during the production of fricatives */s/* and */ʃ/*.
- Results showed a 4 mm difference between */s/* and */ʃ/* (mean of the four normal class individuals), which differs from the 7 mm differences previously reported by Narayanan, Alwan and Haker (1995, p. 1336).

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Conclusions

- There were significant anatomical and posture differences between the two occlusal classes.
- Although the place of articulation and the height of the tongue vary between subjects, the speakers were able to produce suitable acoustic outputs for each fricative.
- The type II class subject needed an adjustment of the articulatory gesture to produce */s/* and */ʃ/* with the required constriction.

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Future Work

- We plan to study the influence of occlusal class in the production of a larger number of speech sounds, using all the individuals included in the XRMB-SDB.
- The acoustic and EGG signals will be used to analyse the observed articulatory gestures.
- We will be using cefalometric measures of each informant to complement our analysis of the speakers' anatomic features.

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