Neuromuscular diagnosis in orthodontics: effects of TENS on maxillo-mandibular relationship

A. MONACO*, R. CATTANE0*, M.C. MARCI*, G. MARZO**, R. GATTO***, M. GIANNONI****

ABSTRACT. Aim This study was conducted in order to assess the changes in the occlusal position of the mandible after Ultra Low Frequency (ULF)-TENS relaxing procedure in children with diagnosed functional mandibular lateral deviation. Methods This study was performed on 20 children, aged between 8 and 12 years, with a mean age of 10 years (SD 0.79) with functional mandibular lateral deviation, diagnosed by clinical and cephalometric evaluation, referred to the Dental Clinic for paediatric dental care. Diagnostic neuromuscular registrations were made for all children, and their casts mounted on articulator Galetti at the myocentric position and compared to casts provided of a wax bite registration in intercuspal position. Results The alignment of the midline after TENS was not punctual (p>0.05). Compared with the existing intercuspal position, neuromuscular registration showed improvement in 10 (50%) patients, 6 patients (30%) showed no changes, while worsening of the tooth-midline discrepancy was assessed in the remaining 4 (20%). The molar relationship did not follow the same trend of the midline because of the three-dimensional changes in the maxillo-mandibular relationship induced by TENS. After TENS there was a significant correlation between midline and right side deviation (r>0.65), there was no correlation between midline and the left side (r<0.65). Furthermore, right molar movement showed no correlation with the contralateral molar (r<0.65). The posterior areas of the arch were moving in a very unpredictable way, resulting in the diagnosis and prognosis of mandibular lateral deviation as absolutely individual and unpredictable. Conclusion This study suggests that TENS recorded occlusion is an interesting diagnostic approach in orthodontics since it allows visualising the trends of the neuromuscular system.

KEYWORDS: TENS, Occlusion, Angle’s Classes, Myo-monitor.

Introduction
Among different malocclusion groups, functional mandibular lateral deviations are considered particularly harmful for the stomatognathic system, especially for the temporomandibular joint [Schokker et al., 1990; Fushima et al., 1999].

Diagnosis of functional lateral deviation is normally carried out on the basis of clinical and cephalometric evaluation [Haraguchi et al., 2002; Truhr et al., 2003; Hayashi et al., 2004; Kawakami et al., 2006]. However, once the condition of mandibular asymmetry is established as functional, the treatment plan considers alignment of the midline through asymmetric extraction [Rebellato, 1998] or asymmetric forces as headgear, elastics or functional devices realized with construction bite centred [Dale, 2005; Paulsen et al., 2000; Brosh et al., 2005; Burstone et al., 2000]. The functional lateral deviation could be the effect of cross or scissor bite, because of the transversal diameters reduction, but, according to previous reports, it could also be due to neuromuscular asymmetry caused by delivery trauma [Dunn 1976; Pirittiniemi et al., 1989; Pirittiniemi et al., 1994; Harila–Kera et al., 2002; Cattaneo et al., 2005] associated with muscular torticollis [Pirittiniemi et al., 1989] or/and ocular defects [Monaco et al., 2006]. In these cases, the results of a constrained position due to orthodontic treatment could determine long-term...
stability problems: occlusion has not to require neuromuscular adaptation, but rather a correct occlusal or orthodontic treatment must adapt occlusion to neuromuscular system, and not vice versa. Therefore, a diagnosis based on intercuspidated casts or cephalometric radiographs is frequently made by orthodontists but it could be a pathogenic point of reference because no information about neuromuscular adaptation is available with this diagnosis [Jankelson, 2005].

Several years ago, different authors have emphasised the importance of rest position and its reproducibility as a diagnostic reference [Thompson, 1951; Perry et al., 1954; Mohamed et al., 1985]. This was not possible until the introduction of new devices for relaxing and recording the muscular status before diagnosis. With the development of the Myo-monitor [Jankelson, 1975], Transcutaneous Electrical Stimulation (TENS) of the motor branches of the V and VII nerves became clinically usable [Jankelson 1973; 1975; 1978]. The primary objective of TENS was to decondition or relax the mandibular and facial musculature in order to identify and establish the true mandibular rest position.

This study was conducted in order to assess changes in the occlusal position of the mandible after ULF (Ultra Low Frequency)-TENS relaxing procedure in children with diagnosed functional mandibular lateral deviation.

Material and methods

This study included 20 subjects aged from 9 to 12 years, mean age 10.2 (SD 0.79), with functional lateral-deviated mandible, selected among children with tooth midline deviation listed to the paediatric dentistry clinic for dental care. All patients presented natural dentition, observable deviation of mandibular and anterior tooth midlines on a functional basis diagnosed by clinical examination, frontal and basal teleradiographies. The subjects were chosen according to the following clinical features: deviated chin from midsagittal plane (drawn perpendicular to the horizontal plane passing through bipupillary and bicommissural lines); lack of alignment of upper and lower labial frena, interincisive lines and molars/canine class asymmetries. At the functional examination: deviation of the incisor midline in maximal intercuspal position, in centric relation and in rest position, deviation during mouth opening, noise and tenderness referred to TMJ. Frontal teleradiographies, taken with mouth open, had to confirm the symmetry of maxillary and mandibular structures. In order to be considered for the study they also had to exhibit the following characteristics:

a. no history of orthodontic or medical treatment;
b. observable deviation of anterior tooth midlines >1,5 mm with alignment at open mouth;
c. absence of skeletal asymmetry;
d. absence of anterior or posterior/lateral cross-bite.

Experimental protocol. Diagnostic neuromuscular registrations were carried out for 20 children. Accurate dental casts were made for each patient. Dental midline asymmetry was measured in relation to the lower and the upper incisal midline. For each cast, reference points were marked on the line from inter-incisors maxillary side (Fig. 1a), a line on molar right and left sides on the horizontal plane (Fig. 1b, 1c). The Myo-monitor was used to relax the mandibular musculature and the resulting rest position was clinically measured and recorded. A myoprint registration was made. A fast-setting acrylic myoprint material was placed over the occlusal surfaces of the mandibular teeth, while the patient stood in a relaxed natural posture. The action of the Myo-monitor stimulated the mandible to lift from rest position to myocentric position. The myoprint was then removed from the mouth, undercutts eliminated and placed between the casts. Several myoprints were realised to check the accuracy of the registration. The casts were mounted in a Galetti articulator and the mounting checked for accuracy by using one or more of the myoprints to confirm that they were interchangeable with the myoprint which had been used for mounting. With the subjects’ casts mounted at myocentric position, a change from habitual occlusion from reference points, was calculated in millimetres and analysed by means of digital gauge. All the measurements were performed twice and the intraexaminer error was calculated by formula s(i) = √σ^2/n.

Statistical analysis. Stata package was used to perform a paired t-test for independent samples comparing mean and variance shift of midline, right molar side and left molar side. Differences with a value of p < .05 were regarded as significant.

A correlative tendency was analysed with Pearson’s correlation coefficient (r). A value of r equal or greater than 0.65 was considered significant.

Two sample proportion tests were carried out on movement direction comparing left or right shifts on the midline, with those on right and left molar side. Differences with a value of p < .05 were regarded as significant. One sample proportion test was performed on each measurement (midline, right molar side, left molar side) considering 0.5 (50%) the probability of
left or right shift. Differences with a value of $p < 0.05$ were regarded as significant.

**Results**

The intra-examiner methodological errors (i) are presented in table 1.

Table 2 shows sample summary statistics regarding the amount of shift after TENS. After TENS procedure, midline shift (MMT) compared to the mandibular midline in habitual occlusion (MMHO) was 1.38 mm (SD 1.23), right molar side (RMT) shift was 1.76 mm (SD 1.41) and left molar side (LMT) was 1.11 (SD 0.98).

Table 3 shows the t-test for the mean shift. No statistical significance was found comparing the
midline mean (MMT) shift to the right molar side shift (RMT) (p=0.11) and to the left molar side shift (LMT) (0.24). Significant difference was revealed comparing right molar side to left molar side shift (p=0.05).

Table 4 shows Pearson’s correlation coefficient among the midline wax centred position (MMHO), the midline shift after TENS (MMT), the right molar side shift after TENS (RMT) and the left molar side after TENS (LMT). All conditions except one showed a low correlation (r<0.65). Only the midline (MMT) and the right molar side amount of shift, after TENS (RMT), showed a correlation (r>0.65).

The mandibular midline (in habitual occlusion) asymmetry is not significantly located on left side compared to the right one (p<0.6) (Table 5). After TENS procedure 8 individuals shifted to right their midline, 7 to left and 5 did not change position. One sample proportion test failed to find statistical significance between right and left shift (p=0.29) with TENS. Right molar side after TENS shifted distally in 12 individuals, mesially in 4 and it did not change in the remaining 4. Significant difference was showed between right and left side shift in right molar side (p=0.02). Left molar side after TENS shifted to mesial in 7 individuals, to distal in 6 and it did not change in 7. No significant difference was found in left molar side shift (p=0.39) (Table 6).

After TENS 10 subjects reduced midline asymmetry, 4 worsened and 6 did not change midline asymmetry. Considering those patients whose midline asymmetry worsened or did not change and comparing them to those individuals with reduced asymmetry, the assessment of the intermaxillary relationship in terms of discrepancy from midline did not show a

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**Table 1** - The intra-observer methodological error s(i)s is calculated from duplicate recordings. S indicates the variance of the total sample of 34, with the values of the left and right sides combined.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Obs</th>
<th>Mean</th>
<th>Std. Dev.</th>
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<tbody>
<tr>
<td>MMT</td>
<td>20</td>
<td>1.38</td>
<td>(1.23)</td>
</tr>
<tr>
<td>RMT</td>
<td>20</td>
<td>1.76</td>
<td>(1.41)</td>
</tr>
<tr>
<td>LMT</td>
<td>20</td>
<td>1.1</td>
<td>(0.98)</td>
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</tbody>
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<th>Variable</th>
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<tr>
<td>MMT</td>
<td>1.0000</td>
<td></td>
</tr>
<tr>
<td>RMT</td>
<td>0.7280</td>
<td>1.0000</td>
</tr>
<tr>
<td>LMT</td>
<td>0.1674</td>
<td>0.1862</td>
</tr>
<tr>
<td>MMHO</td>
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**Table 4** - Pearson’s correlation coefficient among midline in habitual occlusion (MMHO), midline shift after TENS(MMT), right molar side shift after TENS(RMT) and left molar side after TENS(LMT).
neuronal musculature that the left and the right side of the mandible move in a complex manner. For instance, the right side moves mesially, but the left end does not change position or it moves in a non proportional way. If the mandible had simple translation movements on the horizontal plane, like those made on articulators or obtained with manual technique on patients, the amount of lateral shift on midline, left molar and right molar side would be proportional and no significant difference in statistics would be found among midline, left and molar side.

After TENS there was not a high prevalence of reduction of midline discrepancy. Some subjects showed improvement in symmetry, some worsened and some others did not change the midline symmetry. After TENS we found association between lower arch midline and right molar deviation. The left molar position does not seem to be associated with translation on the horizontal plane of midline, probably because of the three-dimensional mandibular repositioning. This result suggests that functional lateral deviation could be an inhomogeneous diagnostic group and confirms that a different approach to muscle balance is needed in order to organise an actual functional orthodontic treatment.

Often the resultant static tooth guided relationship is based on voluntary action by the patient, with or without mandibular guidance or manipulation by the orthodontist. Such a relationship may or may not show statistically significant reduction of asymmetry after TENS (p > 0.05) (Table 7).

Table 8 shows concordance shift among the midline, the right molar and the left molar side. The midline had the same shift direction compared to left molar side in 2 individuals and the opposite shift direction in 18 individuals. The midline had the same shift direction compared to right molar side in 4 individuals and the opposite shift direction in 16 individuals.

Right-left molar side concordance was 10 out of 20 subjects; 10 out of 20 patients had the opposite shift direction on left and right molar side.

**Discussion**

In our sample the habitual occlusion showed that 10 individuals deviated the midline on the right side and 10 individuals on left side. The tooth-midline asymmetry was not significantly located on the left side compared to the right side. These results did not confirm those of other authors [Leigton et al., 1988; Pirtiniemi, 1991] regarding occlusal asymmetry, in which the right side of the dentition (mandibular) is found to be more distalised and analogously the mandibular incisal midline is preferentially located on the right side. After TENS procedure the only significant difference in the amount of shift was between left molar side and right molar side. This means that the left and the right side of the mandible move in a complex manner. For instance, the right side moves mesially, but the left end does not change position or it moves in a non proportional way. If the mandible had simple translation movements on the horizontal plane, like those made on articulators or obtained with manual technique on patients, the amount of lateral shift on midline, left molar and right molar side would be proportional and no significant difference in statistics would be found among midline, left and molar side.

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the truly relaxed relationship of the mandible to the maxilla [Dinam, 1983].

An issue also arises concerning whether a case of worsening of the midline asymmetry orthodontically corrected with midline forced centred is functionally acceptable. Basic reason for the mandibular asymmetric development may lie in asymmetric neuromuscular information where an asymmetry, related to delivery trauma, is a common finding [Dunn, 1976; Pirttiniemi et al., 1989; Pirttiniemi et al., 1994; Harila –Kera et al., 2002; Cattaneo et al., 2005].

Clinicians have repeatedly emphasised the need to take into account the muscular and temporomandibular joint functions, in addiction to the aesthetic alignment of the dental arches. The efficacy of low frequency TENS, Myo monitor, to achieve resting length of muscles provides an ideal tool for the orthodontist to diagnose normal, rather than pathologic, muscle positions [Jankelson, 1979].

These findings are in line with those of Dinham [1983] who considers that certain functional discrepancies become apparent only after neuromuscular analysis.

Conclusion

This study suggests that TENS recorded occlusion in orthodontics is an interesting diagnostic approach, since it allows to visualise the trend of neuromuscular system’s initial reference point based on a relaxed jaw rest position in the neuromuscular system. This may be clinically significant and it stresses the importance of early neuromuscular diagnosis of these malocclusions, in order to be able to plan a correct and aetiological therapy of this complex malocclusion.

References


