

Determined area (DA) treatment goal when treating malocclusions with jaw functional orthopedics (JFO): Contribution to scientific evidence

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Abstract. One of the goals of malocclusion treatment with Jaw Functional Orthopedics (JFO) is to obtain touch of the inferior incisors against the superior incisors in Determinate Area (DA). It is postulated that this touch would bring better stimuli and consequently faster results. Surface electromyographic study of the muscles was performed in Masseter, Temporal and suprahyoid muscles bilaterally from 159 patients undergoing malocclusion treatment with functional orthopedic appliances (FOA). To record muscle electric activity were used a conditioning signal module from Lynx Electronics Ltda with 8 channels, model EMG1000; software AqDAnalysis 4,18 from Lynx Electronics Ltda.; Software Lynx BioInspector 1,8r; passive surface electrodes (Ag/AgCl) from Noraxon Dual Electrodes (USA); dischargeable reference electrodes Kendall Meditrace (Ag/AgCl) – Canada. Frequency calibration was 2000 Hz, with 2048 sample by channel and time 1,024 seconds, and filters regulation was 20 Hz and 1000 Hz. The results found prove that there is a better electromyographic activity (bilaterally balanced) of the studied muscles when there is touch on DA. Conclusion. Touch in DA improves the neuromuscular response of patients treated with JFO. sEMG is a trustable tool to analyze masticatory muscles function for Diagnosis, Treatment and evaluation post treatment/gained objective.

Keywords: jaw functional orthopedics, sEMG, malocclusion, treatment, functional orthopedic appliance.

1. Introduction

Planas since his first publications in late 50's and early 60's stated that the incisive proprioception brings better results when treating malocclusion with neuro-occlusal rehabilitation [1]. He defended the thesis that when the mandible is free to move and during its lateroprotrusive movements or protrusive movements the buccal face inferior incisors touch the palatine face of the superior incisor the contact will trigger better development stimuli to the stomatognathic system (SS). It is good to remember that in Planas' treatment protocol the ideal stimulation is the freedom of mandibular movements and the advances the mandible and keeps it forward in very specific cases [1, 2].

There are several protocols of therapeutic mandibular posture change (TMPC) with functional appliances depending on the type of malocclusion being treated [3]. It is postulated by Simões that when you construct the FOA TMPC and get the touch of the buccal surface of the inferior incisors in its incisal third against the palatine surface of the superior incisors in its incisal third – touch in DA – it is achieved the "supreme neural stimulation" for the treatment of malocclusions. Planas. The aim of this investigation is check, with surface electromyography of bilateral masseter, temporal and suprahyoid muscles, the stimuli improvement when the TMPC reach DA touch if it can be considered as a deal for malocclusions treatments with FOA, and if sEMG is a trustable

tool to analyze masticatory muscles function for Diagnosis, Treatment and evaluation post treatment/ gained objective.

2. Methodology

Using a basis formed by 159 patients under treatment in Specialization course. The protocol followed the course to diagnosis, planification, and treatment includes: Anamnesis, Physical and Functional examination, normal lateral tele radiography (with Bimler and Petrovic cephalometry), tele radiography in NHP (Normal Head Position) (with Rocabado Cephalometry), Gnatostatic casts, mouth and body photos and films, sEMG collected in three times (Diagnosis, Appliance installation, D.A. obtained: Determined Area) by three ways (Diagnosis- isometric contraction, FOA installation and fifteen minutes after this. sEMG examination follow ISEK protocol (bilaterally registration), and used no Normalization, all sEMG signals were analyzed from zero (rest) until the finish (15 seconds). All above data constructed the Tripled List to Diagnosis, Priorities and Treatment (Sakai & Corsi 2005). Appliances were made following instructions contained on Simoes. After obtained D.A., sEMG data were done again in three conditions: rest, isometric contraction with FOA and without it, under same Ambiental conditions (especially electromagnetic area isolation. Materials to sEMG: conditioning signals module from Lynx Electronics Ltda with 8 channels, model EMG1000; software AqDAnalysis 4,18 from Lynx Electronics Ltda.; Software LynxBioInspector 1,8r; passive surface electrodes (Ag/AgCl) from Noraxon Dual Electrodes (USA); dischargeable reference electrodes Kendall Meditrace (Ag/AgCl) – Canada . Frequency calibration was 2000 Hz, with 2048 sample by channel and time 1,024 seconds, and filters regulation was 20 Hz and 1000 Hz. This investigation, authorized by the Research in Humans Ethics Committee of Universidade Estadual de Campinas (UNICAMP), Piracicaba, Brazil under protocol 159/2004.

In this study, patients were evaluated in 3 situations: Diagnosis – Diagnosis session (T1), Functional Orthopedic Appliance (FOA) -the day of functional appliance placement on the mouth (T2) and Determined Area (DA) – when patient maintains the touch between buccal face of inferior incisor against the palatine face of upper incisor without the appliance (T3), and each moments combination justify pairing because same patients were evaluated on 3 conditions what suggest association degree between data observed. For Pared Data it's usually apply Student's T test, Wilcoxon Test and Signal Test. Due to size of the sample (less than 2000), Shapiro-Wilk Test was used, because the sample has a normal distribution at significance level of 5 %.

Grouping analysis were applied to create patient groups with same result, in opposition to patients that show different results in order to evaluate groups and explain different comportments based on distinct morphometrics characteristics and diagnosis/prognosis; these characteristics cannot be controlled at time to choose experimental patients. It was used average grouping method based on data averaged. Method average linkage works with not pondered groups pairs method, using arithmetic average using middle distances.

2.1. Data preparing

Grouping analysis used electromyographic equilibrium data obtained by 3 indicators: Average Difference, Pattern Deviation Difference and Amplitude Difference; these differences calculated based on values observed on muscles Temporalis, Masseter and Suprahyoid. Measurements based on basic parameters (Average, pattern-deviation and Amplitude), obtained on 3 root mean square (RMS) evaluation of each patient for each muscle. After these, differences in absolute terms were calculated on values observed on each side muscles (right and left).

Values closer to zero indicates RMS values with small differences; values more than zero indicates predominance of muscular activity by one side, but without side definition.

Calculus of RMS that is average muscular activity observed from electromyographic study:

$$Eqijkl = RMSijkl - Right / -RMSijkl - Left, \quad (1)$$

where, *i* is patient indicator; *j* is phase indicator (Diagnosis, FOA and DA); *k* statistic observed from 3 collections from same patient (average, pattern-deviation or amplitude), *l* is muscle indicator (Masseter, Temporalis and suprahyoid).

From muscular equilibrium values were developed average comparison studies by paired data tests and grouping analysis, and for this some processing were conducted follow determined by analysis techniques used.

3. Results

Obtained D.A., third sEMG data were done, in Rest, Isometric Contraction with and without FOA. After some statistical treatment, adequate to biological data, were found that D.A. is a good and important goal to malocclusions treatment with JFO. Results showed that functional mandible movements were equal, and sEMG profile were equilibrated bilaterally in all cases, moments, and situations. And more, for first time were obtained Rest registration with results closer to zero (centesimal of microvolt).

Table 1. Supposition study and comparisons of media significant to significance level 5 % based on tests for paired data during swallowing

Variable	Group	H ₀ : Normal	Asymmetry P	Statistical	Statistical test	p value
Me-da-aof-sd	1	-8,5124	0,0044	-1,68	Signaled orders test	0,00195
Am-da-aof-sd	2	-40,6571	0,227	-0,7832	Student's T test	0,00320
Me-aof-dia-sd	3	-0,6286	0,4346	-0,6119	Student's T test	0,00365
Am-aof-dia-me	4	5,7348	0,0135	1,93	Signaled orders test	0,01367
Dp-aof-dia-me	5	0,8451	0,2017	0,1681	Student's T test	0,01406
Am-aof-dia-sd	6	29,8577	0,1572	0,8718	Student's T test	0,01508
Am-aof-dia-se	7	22,7963	0,7679	0,0411	Student's T test	0,02073
Dp-aof-dia-se	8	3,2374	0,4490	0,2878	Student's T test	0,33360

Commentary 1: The Signaled Order Test is recommended because there is no normality signals ($p = 0,0044$), but symmetry, that reveal statistically strong signals ($p = 0,00195$) of differences between real medias on T3 and T2 from right suprahyoid muscle. Difference of media is negative and show that RMS values observed on T2 are bigger than on T3.

Commentary 2: Student's T test shows statistically significant different signals ($p = 0,00320$) of true amplitudes on T3 and T2 from right suprahyoid muscle. The difference of media is negative, and RMS values observed on T2 are more heterogeneous than observed on T3 phase.

Commentary 3: Student's T test show signal statistically significant difference ($p = 0,00365$) from real media on T2 than on T1 of right temporalis muscle showing smaller signal amplitude on T2 concluding that RMS values of T1 are bigger than T2.

Commentary 4: Signal Test reveal true amplitudes signals shows statistically significant difference ($p = 0,01367$) between T1 and T2 on left masseter muscle. This difference is positive, and because of this RMS values on T2 are more heterogeneous than on T1.

Commentary 5: Student's T test shows statistically significant difference ($p = 0,01406$) between true patterns deviation on T2 and T1 from left masseter muscle. RMS values observed on T2 are more heterogeneous than on T1.

Commentary 6: Student's T test shows statistically significant difference ($p = 0,01508$) between true amplitudes on T2 and T1 from right suprahyoid muscle show more heterogeneity on T2.

Commentary 7: Student's T test shows statistically significant difference ($p = 0,02073$) between true amplitude on T2 and T1 form left suprahyoid muscle showing more heterogeneity on T2 than T1 on the signals similar of the finding on the right side.

Commentary 8: Student's T test shows statistically significant difference ($p = 0,03336$) between true pattern deviation on T2 and T1 from left suprahyoid muscle; this difference is positive, and because of this RMS values observed on T2 are more heterogeneous than observed T1.

Table 2. Supposition study and comparison of significant medias at 5 % significance level for more powerful pared data during isometry

Variable	Average	H ₀ : Normal	Asymmetry	Statistical test	Statistic H ₀ : u	p value
H ₀ : $u = 0$						
me-aof-dia-td	-27,4	0,48744	0,40252	Student's T test	-3,06720	0.01341
am-aof-dia-td	-37,0	0,28759	0,15675	Student's T test	-2,47709	0.03516
dp-aof-dia-td	-6,5	0,31435	0,07930	Student's T test	-2,37347	0.04167
me-da-dia-te	-21,5	0,19050	0,73862	Student's T test	-2,36681	0.04213

The recordings of Isometry tests with respective results are shown in Table 2. Look that right temporalis muscle shows significative difference from all parameters (Media, Pattern Deviation and Amplitude) when analyzed the numbers in FOA and Diagnosis periods.

It can be observed that these differences are always negative indicating that medium values and variability are always bigger on T1. Other difference is on left temporalis muscle: difference signal between true medias from T3 and T1, showing media from T3 significantly bigger than T1.

3.1. Pared data tests – equilibrium medias

A second process evaluated equilibrium alterations on muscular activities. Tests are the same, but this time alterations on differences are evaluated on same muscles of same sides. Equilibrated activities result on muscles with approximated values, with media 0 for differences, what is no differences to activities observed on both sides.

It can be observed that there are no detection of equilibrium variation between phases for masseter. Temporalis muscle appear most altered because there are signals of differences on amplitude When are evaluated equilibrium on Diagnosis and FOA phases and on pattern-deviation when analyzed variations of FOA and Diagnosis, and on pattern deviation when analysed variations from FOA / Diagnosis and DA/Diagnosis. Look that only in the last are positive value for difference medias indicating bigger media on DA phase. In all other observations are major variance on Diagnosis phase than another.

In Table 3, signs of differences between real medias from parameter from temporalis muscle are saw on T1 related to T2. Negative media show bigger media on T1. It is analyzed parameters comparison on rest phase where there was no statistically significant difference between comparison electric signals of equilibrium media from T1, T2 and T3. With all of these, it's not possible conclude for significative differences between medias, what suggests profounder studies.

Initially, must consider that any test needs control levels to from data acquisition, but this, many times, do not permit develop experiments on classic form.in this case specifically, where conditions are very well stablished form facial types, different kind of malocclusions, pathology nature, therapeutic resources utilized, an uniformization probably will take a conclusions generalization, and need an enormous number of patients to attend necessities of statistic tests.

It's because of these that suggests data analysis with multivariate statistic that permits comparison with more than one variable, that's it is giving more information to decision, obtaining results more trustable and an explanation for different results observed.

Groupment analysis were conducted to find specific results: equilibrium from supra-hyoidis in deglutition, masseters in isometrics and temporalis in rest.

Groupments were formed by side on each research phase. Relatory of groupment analysis were shown and comented next.

Table 3. Supposition study and comparison of significant medias at 5 % significance level for more powerful pared data during isometry

Variable	Ho: normal	Asymmetry	Statistical test	Statistic Ho: $u = 0$	p Value
eq-am-aof-dia-m	0,00520	-2,12209	Signal test	0,0000	1.00000
eq-qm-qof-dia-s	0,00033	-2,59021	Signal test	-2,0000	0,34375
eq-am-aof-dia-t	0,46232	-0,64320	Student's T test	-1,8096	0,10380
eq-am-da-aof-s	0,00054	2,52508	Signal test	-2,0000	0,34375
eq-am-da-aof-s	0,11273	1,28157	Student's T test	1,6525	0,13283
eq-am-da-aof-t	0,75867	0,09984	Student's T test	1,0018	0,34260
eq-am-da-dia-m	0,02831	-1,12787	Signalated Orders Test	-10,5000	0,32227
eq-am-da-dia-s	0,00435	-0,195955	Signalated Orders Test	0,5000	1,00000
eq-am-da-dia-t	0,04680	-1,50551	Signalated Orders Test	4,5000	0,69531
eq-dp-aof-dia-m	0,00494	-0,195503	Signalated Orders Test	-10,5000	0,32227
eq-dp-aof-dia-s	0,00867	-1,15858	Signalated Orders Test	-1,5000	0,92188
eq-dp-aof-dia-t	0,00012	-2,58704	Signalated Orders Test	-1,0000	0,75391
eq-dp-da-aof-m	0,35500	-0,37245	Student's T test	-1,3488	0,21035
eq-dp-da-aof-s	0,00484	1,81902	Signalated Orders Test	13,5000	0,19336
eq-dp-da-aof-t	0,83117	-0,27241	Student's T test	1,1342	0,28603
eq-dp-da-dia-m	0,00009	-2,75094	Signal Test	-2,0000	0,34375
eq-dp-da-dia-s	0,01428	1,67658	Signalated Orders Test	6,5000	0,55664
eq-dp-da-dia-t	0,04346	-1,61954	Signalated Orders Test	3,5000	0,76953
eq-me-aof-dia-m	0,17822	-0,50132	Student's T test	-1,3410	0,21278
eq-me-aof-dia-s	0,62037	0,52186	Student's T test	0,3294	0,74939
eq-me-aof-dia-t	0,34664	-1,00801	Student's T test	-3,1715	0,01134
eq-me-da-aof-m	0,00098	2,35308	Signal Test	-2,0000	0,34375
eq-me-da-aof-s	0,00533	1,23058	Signalated Orders Test	6,5000	0,55664
eq-me-da-aof-t	0,99553	-0,24404	Student's T test	1,5346	0,15926
eq-me-da-dia-m	0,02928	1,09006	Signalated orders Test	-9,5000	0,37500
eq-me-da-dia-s	0,00950	1,39390	Signalated orders Test	3,5000	0,76953
eq-me-da-dia-t	0,41565	-0,92919	Student's T test	0,5036	0,62662

3.2. Equilibrium on T1 groupment analysis next refers to diagnosis phase

Initially it's possible see trough self-values of covariance matrix (Table 4), a strong association between masseters, temporalis and suprahyoid equilibrium, because with only one principal component it's possible represent 96,57 % of all variations observed on three variables.

With two main components it explained 99 % of variability. Now lets understand groupment history that can be synthetized on next dendrogram as follows.

Table 4. Self-evaluators of covariance matrix. Groupment history. NormRMS

Dist	PST2	Union of groups	Union of groups	Freq
0,0618	9	04-II-141	02-II-135	2
0,1076	8	CL9/3,7	06-II-142	3
0,1248	7	3-II-140	06-II-156	2
0,1768	6	CL8/4,7	05-II-160	4
0,2252	5	CL7/ 4,0	05-II-163	3
0,3941	4	16,7		7
0,4179	3	CL4/2,3	05-II-146	8
0,8943	2	04-II159/ 11,2	CL3	9
1,9798	1	CL2/25,3	04-II-161	10

3.3. Equilibrium in T2 groupment analysis it's pertinent to T2 phase

Results of groupment analysis can be resumed observing dendrogram above. This analysis show that pseudo-t² statistic don't show a peak, that is characteristic of cut because all values are

crests. In this case is suggested adopt cut distance 0,2914 that is last union of two patients that are not in any group.

Table 5. Self-evaluators of covariance matrix

	Self-value	Diference	Proportion	Accumulated
1	996.093357	974.152085	0,9748	0,9748
2	21.941272	18,118859	0,0215	0,9963

Table 6. Groupment history NormRMS

Dist	PST2	Group Union	Group Union	Freq
0.046	9	04-II-141	02-II-135	2
0.091	8	03-II-140	05-II-146	3
0.093	7	CL9	05-II-160	2
0.114	6	05-II-163	06-II-142	4
0.164	5	CL7	CL8	3
0.263	4	CL5	CL6	7
0.291	3	04-II-159	04-II-161	8
0.536	2	CL4	06-II-156	9
1.620	1	Cl3	Cl2	10

4. Discussion

Acceptable is to any malocclusions treatments have a deal, an objective, something concrete. The D.A. announced by Planas on first time for decades ago, shows a different way to obtain results and understand stomatognathic system and its functions, especially mastication. But this kind of postulate need for some researchers, investigations with scientific method, and publications. This is a final part of our investigation started with some case reports, methodology tests, Ambiental and laboratory installations, materials. Is D.A. an adequate deal for malocclusions treatments with FOA? With D.A. muscles involved obtain bilaterally balance? Some care were used (registration form rest until rest, no uses of Normalization, use best materials, sEMG registration obtained bilaterally, lab isolated to electromagnetic influences). Some investigations made years ago, suffered with analogic signals and analysis: Ahlgren, Ingervall and Thilander [4] studied and compared electromyographic activity from temporalis, masseter and orbicularis oris from patients with normal occlusion and with malocclusion Class II on rest, mastication and deglutition. Concluded that there are no differences in rest position between groups. There are agree on conclusion verified EMG activities differences in bilateral registrations, the results published by Moyers [5], Pruzanski [6], Quirch [7], Moss [8], Deguchi et al. [9], Gerstner et al [10], Palomari-Tobo et al [11]. It's understood that these differences show us muscular function executed by different ways between right and left sides. Our data showed bigger Amplitudes, Pattern-Deviation and Media on isometric situation in Masseter on side of Minimal Vertical Dimension (MVD) [1,2] and anterior part Temporalis of opposite side (contralateral). These variations are according Planas's affirmations [2] based on clinical observations. On the other hand, the findings are according to reported by Jarabak [12]; Pancherz and Anehuis [13]; Carels and van Steenberghe [14]; Mushimoto and Mitani [15]; Okeson [16] showing muscular adaptation to stomatognathic system changes.

Following ISEK and SENIAM orientations, with digital registrations and analysis gave to sEMG an higher scientific status. Level and number of scientific publications actually are higher than never; and because of it were assumed these cares. Results obtained and analyzed by some statistical tests and analysis gave consistency to these finds. And this research was not limited to results of a technique: some different appliances were used to these treatments, all of them FOA applied according to patients' necessities; status of Stomatognathic System across and at the end of treatment are fundamental [1, 2]. Because of all of these, optioned to publish this investigation with all data, analysis, report (statistical), based on idea to stimulate other investigations.

Electromyography is a seductive muse because it provides easy access, in detriment, electromyography is too easy to use and consequently too easy to abuse De Luca [17].

5. Conclusions

In D.A. were found a bilateral equilibrium of sEMG registration of the studied muscles, due to a homogenization of bilateral muscle analyzed results,

In D.A. were found a diminishing the sEMG registration in Amplitude, Pattern Deviation and Media, in all situation and moments, giving validation to D.A. as a treatment objective.

sEMG is a trustable tool to analyze masticatory muscles function for Diagnosis, Treatment and evaluation post treatment/ gained objective.

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Data availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Author contributions

Eduardo Sakai: conceptualization, investigation, project management, supervision, methodology, writing-original draft preparation. Luciano Wagner Ribeiro: methodology, investigation. Orlando Santiago Junior: visualization, writing review and editing. Sergio Polizio Terçarolli: methodology, investigation. Jordanna Guedes Amorim: investigation, writing-original draft preparation.

Conflict of interest

The authors declare that they have no conflict of interest.

Ethics statement

The research met all applicable standards for the ethics of experimentation. Permit to perform biomedical investigation was granted by Research in Humans Ethics Committee of Universidade Estadual de Campinas (UNICAMP), Piracicaba, Brazil under protocol 159/2004. Participants provided written informed consent prior to the experiment

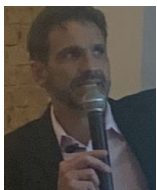
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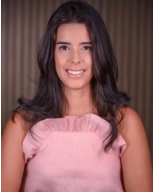
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