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Research Article

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Feet Load Distribution in Subjects with Mandibular Rotations

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Abstract

This study was carried out to evaluate the load distribution along the two feet in subjects with rotated mandibles. This study used the Staticus device from Smylist® to map the foot pressure loads after the three jump test. Data was obtained from 20 subjects. The Staticus data was acquired by the Smylist® analytic software and the load distribution patterns were obtained. Subjects were selected so as to have at least 75% of them exhibiting an asymmetrical vertically displaced pattern. The Smylist® concept has presented a logical sequence of events which leads from a rotated mandible to overloading of one leg based on the complexity of the mandibular rotation. This is the first study ever to digitally ascertain the variation in the load patterns. It was found that in the subjects who exhibited a vertical foot position discrepancy also had a discrepancy in the load patterns and mandibular rotations.

Keywords: Mandible, Rotation, Back Pain, Knee Pain, Smylist, Mandibular, Rotated, Negative, Cascade, Staticus, Asymmetrical, Load, Pattern, Rotation, Negative, Cascade

Introduction

Dentistry is one of the branches of medicine which is heavily dependent on equipment and materials. A good clinicians skills are tremendously enhanced with high quality materials, instruments and equipment. This is an era of digital technology and this technology has touched and benefited dentistry tremendously. One of the most revolutionary concept of modern day dentistry, the Smylist® concept, the creation of Dr. Maria Csillag has maximized the digital technological evolution in creating treatment concepts and plans digitally and used CAD/CAM technology to make complex aesthetics and rehabilitations precise, simple and fast. The Smylist® Aesthetic Design Software and the Smylist® Lab software that generates final 3D STL files for CAD CAM processing for Smile Designs as well as Full Mouth Rehabilitations regarding conscious aesthetic planning, individual midlines, muscle harmony and posture stabilization.

Smylist® has established a number of original and new concepts in dentistry in the past decade. It has been clearly established that improperly placed mandibles, called "mandibular rotations" lead to a complex body compensation which ends up in the feet and how the body is balanced by the individual. The position of the feet can tell a lot but it is only partial information. A complete information data set would be the load pattern in terms of numbers between the two feet and also distribution on each foot. This is possible only if the "natural" load pattern could be recorded digitally to make the diagnostic data complete in all respects.

Smylist® has now come up with a very unique diagnostic device which makes this possible. The "Staticus" is the newest in the Smylist® line of products which makes this kind of diagnosis possible. It is a diagnostic device which is coupled with the Smylist® Digital Assistant software to capture digital data from the feet and provide an in depth analysis to arrive at very pertinent diagnostic patterns to assist and aid the clinician in planning a complete treatment for the patient. Digital devices for capturing foot patterns and loads have been around for almost a decade but the Smylist® concept needed the technology to be tweaked considerably and to be amalgamated into the Smylist® Digital Assistant Software. The Staticus is the outcome of a few years of consistent development work using the latest advancements in such devices. It is extremely easy to use with hardly any learning curve and all it takes is about one minute to complete the test on any individual. It is completely non-invasive, simple and quick and an extra oral diagnostic device. Staticus detects the extent and severity of mandibular rotations and its implication on the TMJ and posture. In fact, it can be used as a routine daily use device for all patients coming into the dental office.

Review of Literature

Pressure sensors have become more and more miniaturized and work at very low energy voltages (5volts) due to the rapid microprocessor technology advancement. Orthopedics and sports medicine have generated the demand for a device to measure foot

plantar pressure values to assess imbalances and to try to enhance sports performances with postural training. There seems to be no reference in the literature of dental research attempting to measure body balances with foot pressure load devices. Based on plantar load data, orthopedics and sports experts have attempted to custom design footwear in an attempt to compensate for improper distribution and balance control and even providing for postural correction. There are also some attempts being made to use this technology for rehabilitating individuals and also for human identification based on these load patterns. All of the above has pushed the research work considerably in making more accurate and improved devices.

The earliest of these devices have been some form of sensory material sandwiched between two printed circuit boards (PCB). These devices are always accompanied by specific imaging softwares which present the digital data in the form of color coded images. Data being captured can be a continuous dynamic video or a static image.

The heart of all available devices is the sensor. There are three possible types of sensors that are used in such devices and capacitive, resistive or piezo. Of these, the resistive sensor made of conductive polymers is most commonly used. The latest technological advancement that is now available is the use of conductive textiles which replace the traditional PCB's. The biggest advantage is the flexibility of the material and specifically for Smylist®, the ability to easily withstand jumps without any potential long term damage to the device.

The Staticus Device

The Staticus is a specifically designed pressure sensitive plantar load measurement device by Smylist®. It is based on Smylist® concepts about how a rotated mandible leads to a body imbalance problem which is reflected on the feet quantitatively as well as qualitatively. This is termed as the "Negative Cascade Effect" and can be referenced in previous publications. Thus far, Smylist® used only visual information of the foot positions as well as wear patterns on foot wear. With the introduction of the "Staticus" now it becomes possible to get precise digital information for a patient. It is a very simple and noninvasive and very fast diagnostic tool which can assess the degree and severity of mandibular rotations and TMJ problems. Thus, it benefits considerably in terms of initial diagnosis and treatment planning and also in the progress of the patient towards a far more balanced and improved posture and good treatment outcomes.

The Staticus has a resistive sensor material which is sandwiched between conductive textile fabric. This makes the device foldable and extremely durable. The underside of Staticus is made of antiskid material which makes it almost fixed to all kinds of even and smooth tiled surfaces. The electronics are built into the Staticus and it works on a 5 volt power supply. It connects to the Smylist® Analytics Software with a USB port which has to be setup in Windows as a COM3 serial port. The power is obtained from the USB port itself. The Staticus is 20.5 inches by 17 inches with a sensing area of 16 inches by 16 inches which suffices for all humans and can take weights upto 150 kgs.

Once plugged in, the Smylist® Digital Assistant automatically detects its presence and is always ready to capture the static data of the final feet position. It is imperative to point out that any data collected on Plantar Pressure of the foot it is critically important to test for the natural loads of the patient and not a fixed position on the device that the subject should be made to stand. Smylist® has conceived a very simple but extremely logical method of arriving at this position. This is by using the Smylist® three jump test. This is described in details in the Materials and Methods section in the following page.

Aims and Objectives

The aims and objectives of this study were as follows

- To digitally assess the discrepancy in the load pattern of the feet with the Staticus device
- To digitally record the foot position pattern and extent of the asymmetrical positions with the Staticus device
- To see the co-relation between the load pattern and the Smylist diagnosis based on the regular signs observed

Materials and Method

A total of 20 subjects were recruited and data collected for all the subjects in the form of a face photograph and the foot picture and the foot pattern after the three jump test on the Smylist® Staticus device.

The inclusion criteria was as follows

- Should be between the age of 20 and 65
- Should not have any history of intraoral trauma
- Should not have advanced active periodontal disease
- Should not be undergoing orthodontic treatment
- Should not have more than 4 missing teeth
- Should not be having Downs syndrome.
- Should not be suffering from any debilitating disease

The photographs made for all the subjects were as follows

- Front face
- Foot position after the Smylist® three jump test

All the photographs were made with a TTL camera. The front face view was taken conventionally for documentation and to generally check for signs of mandibular rotation. The foot position was photographed and recorded on the Staticus device after the patients were put through the Smylist® three jump test. The three jump test is an original concept designed in the Smylist® methodology. Smylist® has demonstrated that a rotated mandible will lead to compensations in the musculoskeletal system and the body compensates in a variety of different ways leading to improper and unbalanced postures. A rotation of the mandible leads to the neck, shoulder, back, hip, legs and feet muscles becoming imbalanced and leading to rotations as a cascade of events. The most important key in diagnosis is to identify these compensations. There would be no purpose served in trying to get a patient into an ideal foot position for purposes of diagnosis. An ideal foot position and thereby an appropriate posture is the goal or therapy and not diagnosis. The Smylist® three jump test is a very logical and appropriate way of assessing body weight distribution. It gives a tremendous amount of information almost instantaneously. The learning curve is almost non-existent and can be applied immediately and the test is carried out in just one minute. Initially the subject is asked to do practice jumps a few times. For practice, the patient is asked to

stand relaxed and then to lightly jump up and down three times. This is to be repeated a few times till the patient is comfortable. (Three times at least). After this the subjects were asked to do the three jump test on the Staticus. The Staticus device is a diagnostic device developed by Smylist® to assess positions as well as load patterns of the feet and provide an accurate diagnosis of the type, extent and severity of the mandibular rotation. More information on the Staticus device has been done in the Introduction section.

The Staticus data was then transcribed to an excel spread sheet. All the subjects photographs were then analysed and the data was added to the basic spreadsheet. This spread sheet data was then statistically analyzed and the results are presented in the tables in this article.

Results

A total of 24 subjects were recruited for this study out of which 14 were female and 10 were males. The age range of the subjects was from 21 to 74. All the subjects fulfilled the inclusion/exclusion criteria specified in the Materials and Methods section. The patients face photographs were assessed for the following parameters based on the Smylist® diagnostic protocol.

a. Angle of the two nasolabial folds
b. A flat or hypertrophied zygomaticus
c. The lower contours of both the eyes
d. Even or uneven hypertrophy of the massetters
e. Even or uneven hypertrophy of the mentalis

The angle of the nasolabial folds was used to classify the subject as not having any lateral rotation or having a right or left rotation of the mandible. A flat or a hypertrophied zygomaticus further confirmed the lateral rotation of the mandible. A flat zygomaticus was indicative of the opposing side lateral rotation. The lower contour of the eye, if pulled downwards indicated the opposing side lateral rotation of the mandible. A hypertrophied masseter on one side indicated a lateral rotation towards that side while a bilateral hypertrophy indicated an upward rotation. A evenly hypertrophied mentalis indicated an upward rotation of the mandible. If the mentalis hypertrophy was uneven it indicated a lateral rotation with possibly an upwards rotation of the mandible.

The foot picture was taken just to confirm the status of the foot pattern generated by the “Staticus”. There are a number of revelations which were confirmed with the Staticus data generated. Not only did it evaluate the relative front/back position of the feet, the loading of the two feet was available in terms of actual quantitative numbers. These numbers were used and put into the tables. In this study the actual vertical front back discrepancy and the load differential between the right and left leg was computed using the Staticus.

Figure 1: A front also shows the right foot place well behind the left face picture demonstrating signs of a right rotated mandible. The foot position after the Smylist® three jump test

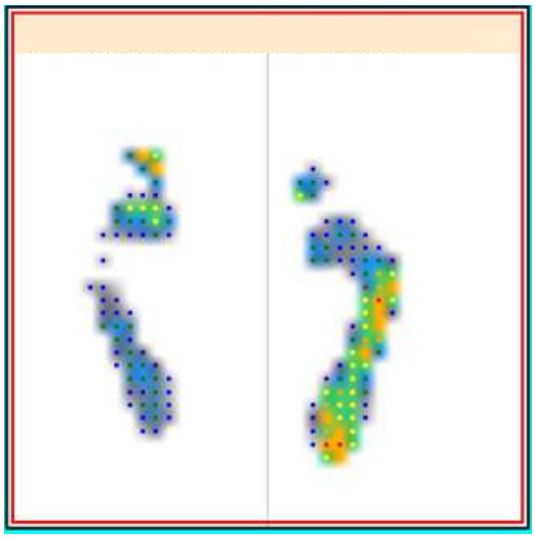

Figure 2: The foot pattern obtained from the Smylist Analytic Software after the Three Jump Test on the Staticus

All the 24 subjects exhibited signs of mandibular rotation. The subjects are divided into 4 groups in the table. There were a few of these who also had an upward rotated mandible in conjunction with the right/left rotation. These were five subjects. The right rotated group was almost double that of the left rotated group. The analysis of the feet was done separately and the face diagnosis from the pictures was done independent of each other.

Table 1: Mandibular Rotations observed on the photographs

Type of Rotation	Subjects	Percentage
Right Rotated	13	54.16%
Left Rotated	6	25%
Right+Upward Rotated	3	12.5 %
Left+Upward Rotated	2	8.33%

The foot pattern data from Staticus was then tabulated for foot position as well as for load discrepancy between the two feet.

Table 2: Foot position discrepancy as seen on the Staticus foot pattern

Foot Pattern	Subjects	Percentage	Mandibular Rotation
Both symmetrical	1	4.16 %	1
Right foot behind	16	66.66 %	16
Left foot behind	7	29.16%	7

Table two demonstrates that the Staticus foot pattern was in complete accordance with the observations of rotation as seen on the photographs. All subjects with the left foot behind had a left rotated mandible and all those with the right rotated mandible had the right foot behind. The next table displays the load pattern on the two feet for all the subjects. There was only one subject with no discrepancy in foot position but had a mildly right rotated mandible. The discrepancy between foot loading ranged from zero for the one subject with no discrepancy all the way to 68 mm.

It was generally observed that a majority of the patients who had a foot position discrepancy loaded the foot which was behind. Of the 23 cases who had a foot position discrepancy, 21 showed a greater load on the foot which was behind. This meant that the foot on the side of the lateral rotation was being favoured due to the body compensation. Only 2 cases showed a greater load on the foot that was in front. The reason for these two cases is that the rotation has progressed so aggressively that the body load pattern is being over compensated and shifted to the contra lateral side. All the 24 subjects showed an uneven load distribution. The next table shows the subjects grouped in seven categories based on load discrepancy.

Table 3: Load discrepancy in the two feet

Load Discrepancy (Groups by %)	Subjects	Percentage
Zero to 4%	2	8.33%
4% to 8%	6	25%
8% to 12%	6	25%
12% to 16%	1	4.16%
16% to 20%	4	16.66%
Greater than 20%	3	12.5%
Negative Load	2	8.33%

The above data is the first of its kind and can be the baseline for future load discrepancy testing studies with the Staticus. The two subjects exhibiting a negative load pattern is due to an overcompensation and will lead to severe systemic problems. The negative load discrepancy in these two subjects was 8.6% and 4.4% and both were cases of lateral rotation coupled with over rotation. This kind of information has never been available and will prove to be invaluable for a Smylist® dentist in formulating a treatment plan as well as letting the patient know the severity of the rotation problem. Such cases have to be classified as severe cases.

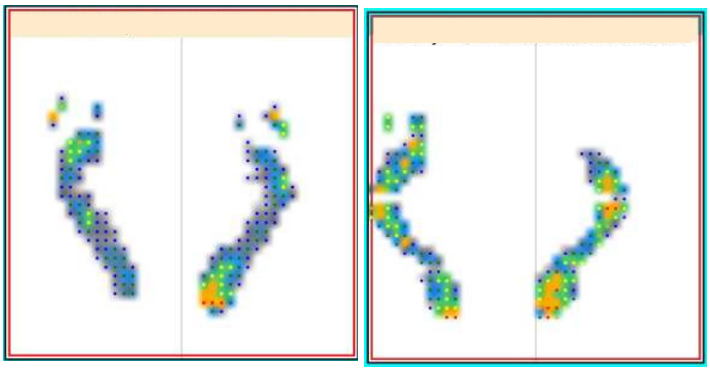

Figure 3: The foot patterns of the two subjects with a negative loading with severe rotation and body compensation

The next table groups the subjects based on the value of foot position discrepancy in millimeters.

Table 4: Foot position discrepancy in mm

Foot position discrepancy (Grouped by mm)	Subjects	Percentage
1-8 mm	2	8.69 %
8-16 mm	7	30.43%
16-24 mm	3	13.04%
24-32 mm	6	26.08%
32-40mm	1	4.34%
Greater than 40 mm	4	17.39%

The above data does not reveal any significant pattern in the foot distance discrepancy. Even when compared with the load discrepancy in these groups, there does not seem to be a pattern. Since there are no previous studies which have attempted to measure this distance this could only be considered as a base line data for future studies.

Discussion

This is the first ever study carried out to find out load distribution on the two feet measured after getting the subject into a natural tooth position. This natural body balance and foot position is the Smylist® three jump test position. As explained earlier this is an ingenious and extremely simplistic method of bringing any individual into the most natural postural standing position. The device used to find out the loads is the "Staticus". This is also the first ever study published on the usage of the Staticus. The device is essentially a pressure sensitive mat on which the patient has to stand and perform the three jump test. Even though there are a number of pressure mats used by Orthoapaedics, podiatrists and sports medicine specialists, none of them are used with the three jump method or anything similar to obtain the natural foot/posture position.

The Staticus has provided excellent data to confirm how the body is compensating for mandibular rotations and what is the extent and severity of the rotation and the outcome on the musculo skeletal system and other organs of the body. The excellent finding of foot position discrepancy in actual numbers is a very important number in terms of mandibular rotation. Still more important and critical is the load pattern on the feet. The discrepancy of the load between the two feet is the single most critical finding from this study. When closely analysed this table presented the most valuable information. There has been one study done previously with only photographic evidence taken after the three jump test to correlate foot positions with mandibular rotations. The findings of the current study further validated the mandibular rotation with significant digital data which recorded the exact relative position of the two feet. A direct co-relation was observed between facial photograph diagnosis of mandibular rotations and the digital foot positions on the Staticus digital output. Mandibular rotations have been diagnosed from the wrinkles on the face and now there is full evidence obtained from the load patterns of the feet. Every case in this study corresponded with foot positions and right/left rotation of the mandible.

The load differential data between the two feet was a revelation. It has so far not at all been possible to get this data to ascertain body compensations for rotated mandibles. The Staticus generates an instant report on the foot load discrepancy. The logical flow of the Negative Cascade Effect states that the foot which is behind in position will have a much greater load. Most of the subjects presented with this pattern of load distribution. Upon close scrutiny of the data, it was realized that the load differential should be divided into seven groups. The ideal body balance is when the two feet share an identical load, which would mean a zero value. This is an ideal and in all probability extremely rare. This data shows that the first group of zero to 4% discrepancy could be considered acceptable and that the negative cascade effect has not kicked in. The mandible may be in the G space (the most balanced position of the mandible) or it may be possible that the mandible is rotated but the negative cascade effect has not been initiated and the body is still more or less in balance. The rotation is evidently not very severe in these cases. There were less than 10% of the subjects who were in this group.

All those in the 4-8% group have started having body compensations to the rotated mandible. The rotation is not extremely severe and nor will be the systemic problems associated with a rotated mandible. The subsequent group of 8-12% load differential would be the moderate rotations and body compensations. These subjects will have some or the other systemic problem which has origins in the rotated mandible. Both these groups accounted for 25% of the cases each. This indicates that marginally more than 50% of the cases were in the severe and very severe conditions.

The next two groups very the 12-16% and the 16-20% load differentials. These two groups accounted for about 20% of the subjects. These evidently will be the ones with moderate to severe rotation and body compensations in a progression of events. The next group was all cases with greater than 20% load differential. It was decided that anything more than a 20% load differential was a severe situation and it did not matter how much was the actual differential. Slightly more than 12% of the cases were in this group. With a greater than 20% imbalance the body will develop a number of variations in trying to counter the muscular problems created. One critical factor which would play a major role will be the age of the patient. The period of time with severely rotated mandibles will increase the body compensatory mechanisms and lead to more complex problems. This data suggests that studies

with the Staticus should be carried out with more subjects and additional parameters of age groups built into the analysis.

The last group was the major revelation. This was a small number with only 2 subjects presenting a negative load. Instead of the foot behind presenting a greater loading it was the foot in front which presented a greater load. This indicated that the subject was very severely overcompensating and was shifting the load to the non-rotated side because of the high severity and intensity of lateral rotation and an exaggerated compensation by the body to counter this muscular problem. A negative load is an increased load on the side where the foot is in front instead of the vast majority where the increased load is on the foot which is behind. This happens only at an advanced stage of the lateral mandibular rotation. The situation always starts with the individual moving the foot behind on the side of the mandibular rotation. This is accompanied by an increased load on that side of the body. Over time as the rotation becomes more severe or the body compensation becomes more severe, the load differential keeps increasing. In some individuals at some point of time, the overload becomes so severe that a reverse body compensation is initiated and the foot in front actually gets overloaded. This is a condition of an extremely severe rotation as well as body compensation. Such individuals will present severe asymmetry in the body and the muscles with a myriad of systemic issues. This finding of the negative overload is a strong indicator of the need of a follow up study with a much larger number of subjects to ascertain the incidence of negative load discrepancies.

Conclusions

It can be concluded from this study that the Staticus generates very precise and accurate information of the body compensatory mechanisms and at the same time also gives much more additional information pertaining to the loads on the two feet as well as the load differential between the heel of each foot and the frontal area. The use of the Staticus will allow the clinician to be able to confirm and ascertain the benefits of immediate deprogramming and also immediate therapy with a Smylist® positioner as well as evaluation after the definitive therapy is completed. The Smylist® Digital Assistant software reports generated from the Staticus data is a major step ahead in predictive diagnosis and it is recommended that this device should become a statutory part of new patient protocol in all private practices [1-10].

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