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(Προηγούμενος τίτλος: Οδοντοστοματολογικά Νέα)

▪Εξαμηνιαία περιοδική έκδοση της Στοματολογικής Εταιρείας Θεσσαλίας

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3. **Βιβλιογραφία:** Αναγράφεται σε ξεχωριστή σελίδα, μετά το τέλος του άρθρου, κατ' αλφαβητική σειρά, σύμφωνα με τους κανόνες τού Index Medicus. Δηλαδή, αναγράφονται τα επώνυμα των συγγραφέων, τα αρχικά των ονομάτων τους, ο τίτλος της εργασίας, το όνομα του περιοδικού με τις ανάλογες διεθνείς συντομεύσεις και το έτος δημοσίευσης, π.χ.: Kau CH, Richmond S, Palomo JM, Hans MG. Three dimensional cone beam computerized tomography in orthodontics. Journal of Orthodontics 2005; 32: 282-293.

   Αναφορές σε βιβλία, ως εξής: Moorrees C F A. The dentition of the growing child. Harvard University Press, Cambridge 1959.

   Στο κείμενο, οι βιβλιογραφικές παραπομπές αναφέρονται με τα ονόματα των συγγραφέων και το έτος δημοσίευσης του άρθρου. Όταν οι συγγραφείς είναι 2, αναφέρονται και τα δύο ονόματα, σε περισσότερους των δύο, αναφέρεται ο πρώτος και ακολουθεί *και συν.*
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–Οι εργασίες, που δημοσιεύονται, αποτελούν πνευματική ιδιοκτησία του συγγραφέα και του περιοδικού. Η δημοσίευση μιας εργασίας δεν συνεπάγεται και αποδοχή των απόψεων των συγγραφέων από πλευράς περιοδικού.

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Any **article** must include 1. Abstract of 150 words or less 2. Introduction indicating the purpose of the study 3. Description of the methods and materials used 4. Results 5. Discussion 6. Conclusions and 7. References. A summary in English or Greek of 400 words or less must be provided at the end.

References should be written in a separate page and in alphabetic order. References in the text should be quoted by the author's name(s) and the year of publication. In the case of two authors both names should be stated. If there are more than two authors only the first author plus et al. is used. References to papers must be given as follows: Kau CH, Richmond S, Palomo JM, Hans MG. Three dimensional cone beam computerized tomography in orthodontics. Journal of Orthodontics 2005; 32: 282-293. References to books must be given as follows: Moorrees C F A. The dentition of the growing child. Harvard University Press, Cambridge 1959.

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EUROPEAN JOURNAL
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Editor's Message

Dear Colleagues,

The Editorial Board accepts articles that meet the rules of evidence-based dentistry and also provide a practical use for the general dentists and/or specialists in dentistry. As it has been stated, the first issue of each year will be circulated electronically in June via our website. In December, the first issue will be published again together with the second issue of the year.

It has been decided that articles with the following topics will be published in our second 2015 issue: tongue coating and oral malodor , esthetic restorations of teeth with resin composite before and after orthodontic therapy, functional displacement of the mandible due to abnormal tooth contact and use of cone-beam computed tomography (CBCT) in general dentistry.

The Editorial Board is looking for immediate scientific consideration of all articles from the journal's reviewers and welcomes all comments and suggestions of our colleagues.

Sincerely yours,

Apostolos Tsolakis
Assistant Professor of Orthodontics,
University of Athens

European Journal of Dental Science 2015, 2:5-12.

The role of tongue coating in oral malodor in greek patients.

Zafeiroula Yfanti[1], Michalis Nikitakos[2], Theodoros Stefaniotis[3], Catherine Donta[4], Kostas Tsiklakis[5]

SUMMARY

Oral malodor in patients with free medical history has been associated with the increased number of volatile sulfur compounds (VSC's) and this is possibly due to the growth of the microbial load. Coating on the dorsal surface of the tongue appears to be the main source of producing compounds such as hydrogen sulfide (H_2S), methyl mercaptan (CH_3SH) and dimethyl sulfide [$(CH_3)_2S$].

The purpose of this research work was to determine the levels of VSC's in relation to the coating on the dorsal surface of the tongue and emphasize the role of this coating in the appearance of halitosis.

For this purpose 50 patients (23 men and 27 women) aged between 33 and 65 years old were selected from the Department of Oral Diagnosis and Radiology, School of Dentistry, University of Athens by applying exclusion criteria. These patients during their medical history reported occasional or permanent oral malodor and after clinical examination coating was found on the dorsal surface of the tongue.

The patients were randomly divided into two equal groups. Group 1 was consisted of 25 patients that they used a tongue scraper for cleaning the dorsal surface of the tongue and group 2 consisted of 25 patients who did not use the scraper. In both groups the tongue coating was measured based on the index of Yaegaki et al. 2000 in two different sessions, and measurements of the three volatile sulfur compounds were performed using Oral ChromaTM, a device with a function based on gas chromatography. Statistic tables were created and statistical analysis was performed at a significance level of < 0.05 with the use of the statistical package SPSS.17 for the analysis of the findings.

Statistically significant reduction ($P< 0.05$) of the index of the tongue coating and the levels of the three volatile sulphur compounds was found in the group 1 in comparison to the group 2.

In conclusion, the subtraction of the tongue coating reduces the levels of volatile sulfur compounds and therefore oral malodor is decreased.

►**Key–Words:** oral malodor, tongue coating, volatile sulphur compounds

INTRODUCTION

Terms such as halitosis, oral malodor and breath malodor, are used to describe the odorous exhaled air from the oral cavity (Figueiredo et al. 2002, Iwanicka-Grzegorek et al. 2005, Van den Velde et al. 2009). The main cause of oral malodor is the metabolic activity of mouth's microbial flora that produces a variety of malodorous volatile sulfur compounds or simply referred as VSC's (Tangerman and

–Part of this work was presented at the 3rd National Congress of Oral Pathology in Athens, 20 & 21 March 2015, Athens.

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Winkel 2010, Kuo et al. 2013). From these volatile sulfur compounds, mainly hydrogen sulphide (H_2S), methyl mercaptan (CH_3SH) and dimethyl sulfide (CH_3SCH_3) are responsible for oral malodor (Morita and Wang 2002, Awano et al. 2004, Winkel and Tangerman 2008).

Latest research reports concerning the intraoral cause of oral malodor, concluded that local factors, such as poor oral hygiene, extensive decayed cavities, inflammatory diseases of the periodontium, hairy, coated and fissured tongue, ulcers and neoplastic conditions might be responsible (Pedrazzi et al. 2004, Androutsou-Pantziou 2006, Quirynen et al. 2009).

The rate of intraoral causes for oral malodor is reported very high and might reach 90% (Winkel and Tangerman 2008, Kuo et al. 2013, Ileri Keceli et al. 2015). Specifically, concerning the tongue it has been proved that the dorsal surface may be the main source of oral malodor since the presence of papillae as well as its large surface, constitutes perhaps, a unique ecological position for gathering food residues and microorganisms (Porter and Scully 2006, van den Broek et al. 2007, Kamaraj et al. 2014). Interestingly, research findings indicate that the number of bacteria increases significantly when coating on the dorsal surface of the tongue is present (fig. 1, fig. 2· Roldan et al. 2003, Ciçek et al. 2003, Kamaraj et al. 2011, Dudzik et al. 2015).

Apart from the demonstrated intrinsic factors in the appearance of oral malodor, there are many other studies indicating a close relationship between the extrinsic factors and the appearance of halitosis (Sanz et al. 2001, Hoshi et al. 2002). The implication of extrinsic factors seems to be small, about 10%, thus the combination of extrinsic and intrinsic factors should be of concern for halitosis (Iwanicka-Grzegorek et al. 2005, van den Broek et al. 2007). Also, under no circumstances, the psychological factor of each patient should and the way each patient perceives this situation should not be underestimated since it seems to play an important role in the presence of bad breath (Papaioannou and Dereka 2009, Dudzik et al. 2015). The investigation of halitosis should be a result of gathering as much information as possible. Patient history information must be evaluated in a detail (Donaldson et al. 2007, Bollen and Beikler 2012).

In addition, various periodontal and tongue coating indices (table 1) from the clinical examination of the patients can contribute (Yaegaki et al. 2000, Pedrazzi et al. 2004, Quirynen et al. 2009). As it is apparent from the literature, significant assistance for

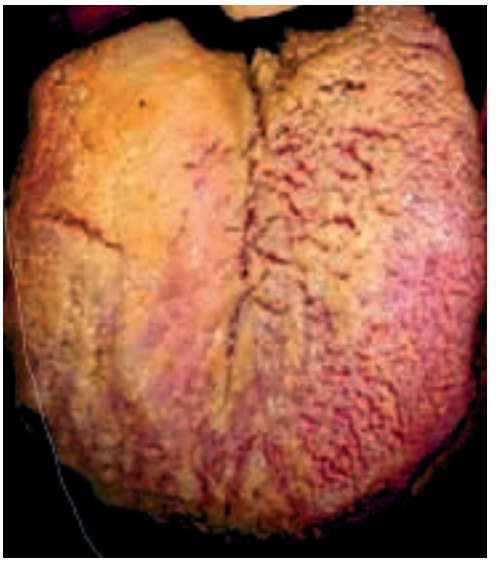


Fig. 1. *Thick white coating covering almost total dorsal surface of the tongue (Jie et al. 2015).*

Fig. 2. *Thin yellow coating covering over two thirds of the dorsal surface of the tongue (Zhu et al. 2014).*

the investigation of oral malodor have provided modern laboratory methods and microbiological tests, (Hunter et al. 2003, Sopapornamorn et al. 2006).

From the laboratory methods that may be either by organoleptic assessment, gas chromatography or measurement devices of volatile sulfur compounds, some are used for research studies and others are of more practical everyday use (Tanda et al. 2007, Seung et al. 2008, Dudzik et al. 2015). It is also worth emphasizing to the offer of microbiological tests for the investigation of halitosis such as the BANA test or the b-galactosidase test because they specify well

Table 1. *Classification of severity and extent of tongue coating Yaegaki et al. (2000).*

Indicator	Quantity and extent of tongue coating
0	No visible coating
1	> 1/3 covered by thin coating
2	> 2/3 covered by thin coating or > 1/3 covered by thick coating
3	> 2/3 covered by thick coating

enough the composition of the biofilms (Morita and Wang 2001, Sterer et al. 2002, Kazor et al. 2003). The purpose of this research work was to determine the levels of VSC's in relation to the coating on the dorsal surface of the tongue in greek patients and emphasize the role of this coating in the presence of halitosis.

MATERIALS AND METHODS

50 patients who during their medical history reported occasional or permanent oral malodor and during clinical examination coating on the dorsal surface of the tongue was found, were selected from the Department of Oral Diagnosis and Radiology, Dental School, University of Athens. The age of the patients ranged from 33-65 years with a mean age of 50.35 years. 23 patients were men and 27 women with a mean age of 51 years and 49.82 years respectively. The present study was a randomized clinical intervention study with duration of three months. This research was approved by the Ethics Committee of the Dental School of Athens.

Patient selection criteria were: a) occasional or permanent oral malodor and b) coating on the dorsal surface of the tongue. Exclusion criteria were: general diseases such as diabetes, disorders of the kidneys, the liver or the digestive system, neoplasm of the upper respiratory tract and the oral cavity. We also excluded patients with syndromes or patients taking drugs that may cause xerostomia, edentulous patients, pregnant women, patients with extensive carious cavities, chronic generalized gingivitis or periodontitis and poor oral hygiene.

All participants signed a consent form in order to participate in the research. Patients were randomly divided into two groups each consisted of 25 people (group 1 and group 2). Group 1 consisted of 12 men and 13 women with an average age of 49.21 years.

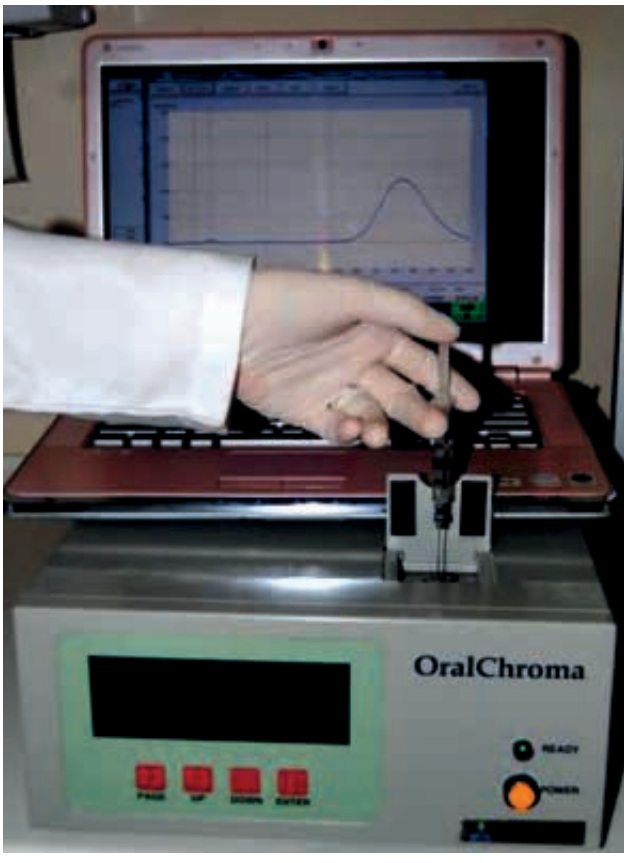
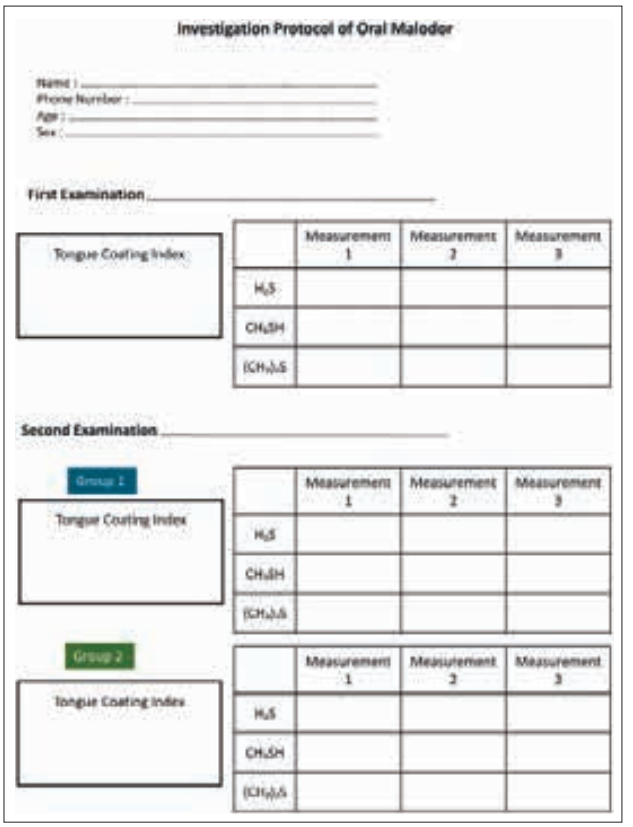


Fig. 3. *The Oral ChromaTM device connected to a computer during injection of a sample.*

Group 2 consisted of 14 women and 11 men with an average age of 53 years. Group 1 patients were given a tongue scraper for removing the coating from the dorsal surface of the tongue, using it 3 times daily without any other change in the frequency and the way of their oral hygiene. Group 2 patients were not given a tongue scraper.

The determination of the tongue coating both in extent and thickness was measured with the aid of the index Yaegaki et al. (2000, fig. 3). Measurements in ppb (parts per billion) of the VSC's were performed by means of the device Oral Chroma^{TM} (Abilit Corporation, Osaka, Japan) in the Department of Oral Diagnosis and Radiology, Dental School, University of Athens (fig. 3). The device was connected to a computer and with the use of the appropriate software, graphical representation of the measurements was provided. Specifically in each patient, three consecutive measurements were performed which collected air samples during inhalation with a special plastic syringe which remained in the oral cavity for 30 seconds. After three aspirations the syringe was removed from the patient's mouth and was inserted


Investigation Protocol of Oral Malodor

Name :
Phone Number :
Age :
Sex :

First Examination

Tongue Coating Index		Measurement 1	Measurement 2	Measurement 3
	H_2S			
	CH_3SH			
	$(CH_3)_2S$			

Second Examination

Group 1

Tongue Coating Index		Measurement 1	Measurement 2	Measurement 3
	H_2S			
	CH_3SH			
	$(CH_3)_2S$			

Group 2

Tongue Coating Index		Measurement 1	Measurement 2	Measurement 3
	H_2S			
	CH_3SH			
	$(CH_3)_2S$			

Fig. 4.*Measurement form of the tongue coating index and the VSCs'.*

in a special slot on the device. The duration of each measurement was 8 minutes. Within seven days the patients from both groups were reviewed. A second recording of the tongue coating was performed and three consecutive measurements were repeated with the Oral Chroma™ device. The measurements of the tongue coating index and the VSCs' from the first evaluation and from the follow-up for both groups were recorded on a special form (fig. 4).

Mean values and standard deviations of the tongue coating index and of the VSC's were determined and charts and tables were created. These findings were statistically evaluated using the SPSS. 17 (SPSS Inc. Chicago, IL., USA) at $p<0.05$.

RESULTS

In Group 1 the mean ratio of the tongue coating was initially 2.29 and during follow-up was 1.08. The difference was statistically significant ($p<0.05$, Chart 1). In group 2 the mean tongue coating ratio both for the first evaluation and for the follow-up was 2.33 (Chart 2).

Upon the first examination in group 1 the mean concentration of hydrogen sulfide (H_2S) was at 114.36 ppb while during follow-up 55.57 ppb, showing a statistically significant difference ($P < 0.05$). In group 2, the mean concentration for the first examination was 120.12 ppb and during follow-up 123.07 ppb (table 2).

Upon the first examination in group 1 the mean concentration of methyl mercaptan (CH_3SH) was at 56/86 ppb and at follow-up 22.21 ppb, showing a statistically significant difference ($P < 0.05$). In group 2, the mean concentration for the first examination

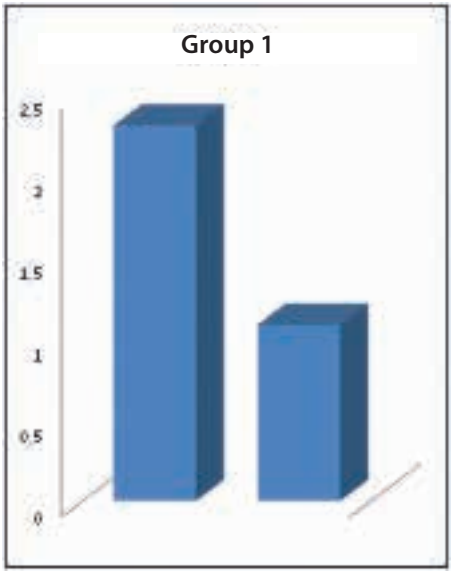


Chart 1. *Mean values of the tongue coating index Yaegaki et al. (2000) in group 1 at the first and the second examination.*

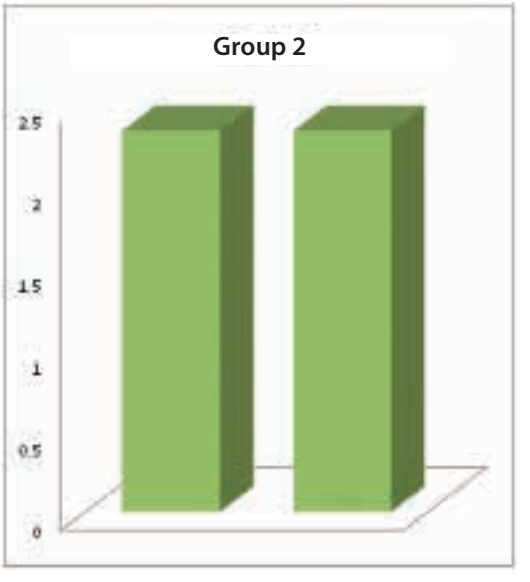


Chart 2. *Mean values of the tongue coating index Yaegaki et al. (2000) in group 2 at the first and the second examination.*

Examination	Group 1	Group 2
First	**114,36**	120,12
Second	**55,57**	123,07

Table 2. *Mean concentrations of hydrogen sulphide (H_2S) of both groups at the first and the second examination (measurements in ppb, p<0.05).*

Examination	Group 1	Group 2
First	**56,86**	33,35
Second	**22,21**	29,28

Table 3. *Mean concentrations of methyl mercaptan (CH_3SH) of both groups at the first and the second examination (measurements in ppb, p<0.05).*

Examination	Group 1	Group 2
First	**16,29**	14,22
Second	**6,60**	12,10

Table 4. *Mean concentrations of dimethyl sulfide [$(CH_3)_2S$] of both groups at the first and the second examination (measurements in ppb, p<0.05).*

was 33.35 ppb while during follow-up was 29.28 ppb (table 3).

Upon the first examination in group 1 the mean concentration of dimethyl sulfide [$(CH_3)_2S$] was 16.29 ppb and at follow-up was 6.60 ppb, showing a statistically significant difference ($p<0.05$). In group 2, the mean concentration for the first examination was 14.22 ppb while during follow-up was 12.10 ppb (table 4).

DISCUSSION

Halitosis has a multifactorial cause and for this reason many researchers investigate the occurrence of the causative factors but also contribute to the effort of identifying the main causative agent (Washio et al. 2005, Krespi et al. 2006, Tas et al. 2011, Bollen and Beiker 2012). From the review of the relevant literature it seems that halitosis originates from the oral cavity at a rate of approximately 90% (Seemann et al. 2006, Winkel and Tangerman 2008, Suzuki et al. 2011, Kuo et al. 2013, Ileri Keceli et al. 2015). Further investigation of halitosis, according to recent findings, led to the conclusion that this is largely due to the presence of microorganisms in the oral cavity (Ximenez-Fyvie et al. 2000, Socransky et al. 2002). It is a fact that in the oral cavity there are more than 700 species of bacteria that constitute the normal microbial flora of the mouth (Washio et al. 2005, Kamaraj et al. 2014). The disruption of the normal microbial flora of the oral cavity, under appropriate conditions, can also be a pathological factor in the appearance of oral malodor (Kazor et al. 2003, Androutsou-Pantziou 2006). Also, it is known that in the oral cavity there are places that pathogenic bacteria can be developed under certain conditions and can contribute to the development of halitosis (Allaker et al. 2009, Scully and Greenman 2012).

Research studies showed that the dorsal surface of the tongue, which can be covered by different degrees of coating, can be the cause of oral malodor at a rate of 40% (Gomez et al. 2001, Lundgren et al. 2007). This high percentage as well as the findings that the tongue coating has numerous bacteria at high levels, is still a motivation for research (Papaioannou and Dereka 2009, Babacan et al. 2011). Furthermore it has been demonstrated that especially the anaerobic and gram-negative bacteria that are primarily detected in the pathological microbial flora of the dorsal surface of the tongue have been associated with the appearance of oral malodor (Yaegaki et al. 2000, Sanz et al. 2001, Outhouse et al. 2006).

Recent data of research has given special attention to the reduction of the microbial load in the oral cavity and particularly on the reduction of the tongue coating (Gomez et al. 2001, Winkel et al. 2003). The purpose of several studies is to investigate whether the reduction in the tongue coating by mechanical means, chemical means or a combination of both can contribute in the decrease of oral malodor (Morita et al. 2002, Van Tornout et al. 2012, Amou et al. 2014). For the investigation of tongue's coating role in oral malodor many researchers related the amount of the coating with the concentrations of the volatile sulfur compounds. These findings revealed that the reduction of the amount of tongue's coating is associated with a corresponding reduction of the volatile sulfur compounds (Scully and Greenman 2012). As the halitosis is due to the metabolic activity of the microbial flora of the mouth and the production of volatile sulfur compounds (Awano et al. 2004, Pedrazzi et al. 2004), a reduction of the microbial load can lead to the reduction of oral malodor In this work, which was intended to identify the role of tongue

coating in bad breath, according to the methodology described, our findings emerged that they were compatible with other investigators' (Scully and Greenman 2008, Awano et al. 2004, Quirynen et al. 2004) indicating that the reduction of tongue coating is associated statistically significantly with the decrease of concentrations of volatile sulfur compounds. The findings of this work in terms of the concentration of volatile sulfur compounds, show concurrence with other studies that high concentrations of hydrogen sulphide and methyl mercaptan are associated with endogenous origin (Yoshimura et al. 2000, Awano et al. 2004) while levels of dimethyl sulfide concentrations usually characterize extraoral origin oral malodor (Scully and Greenman 2012).

In addition the results show that the reduction of the tongue coating assay values is associated with a corresponding reduction of concentrations of volatile sulfur compounds, in agreement with the researchers' thought that engaged the treatment of bad breath and their protocols include the cleaning of the tongue (Morita et al. 2002, Papaioannou and Dereka 2009, Amou et al. 2014). At this point it should be remarked that the next research effort should continue in order to identify the specific incriminating microbes for bad breath which so far has not been demonstrated (Papaioannou and Dereka 2009). The findings of this study, in agreement with other surveys, emphasize the role of the coating of the tongue that is still considered to be a key precipitating factor for halitosis (Ohmori et al. 2005, Blom et al. 2012, Dudzik et al. 2015).

CONCLUSIONS

1. The reduction of the amount of the tongue coating reduces the levels of the three volatile sulfur compounds: hydrogen sulfide, methyl mercaptan and dimethyl sulfide.
2. The reduction of the amount of the tongue coating and the levels of the three volatile sulfur compounds lead to the decrease of oral malodor.

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Esthetic restorations of teeth with resin composite before and after orthodontic therapy.

Eva-Eleni Achilleos[1], Charikleia Paximada[2]

SUMMARY

Aim: *Small aesthetic corrections are often essential either before the beginning of an orthodontic treatment or after the completion of the orthodontic therapy for the esthetic improvement of anterior teeth.*

Background: *Before the orthodontic treatment, operative treatment is possibly required for the placement of the orthodontic mechanisms/brackets and after the orthodontic treatment it is usually essential for the completion of the final result. With the contribution of restorative dentistry, problems like abnormal tooth shape, small lateral incisors, rotated, discolored teeth, diastemas and also white spot lesions that may create esthetic problem of the anterior teeth, can be easily be handled with the aid of bonding and the use of the layering technique of resin composites while is required minimal or no intervention of dental tissues.*

Cases description: *Four cases with problems like diastemas, peg lateral, missing lateral incisors and white spots lesions were managed with the aid of resin composites before and after orthodontic therapy.*

Conclusion: *Many problems in orthodontic patients can be easily and conservatively be handled with the aid of resin composites. At the same time, the operation must be performed with as much minimal intervention of the dental tissues as possible, a very important issue, while these patients are often quite young.*

Clinical significance: *The collaboration of Operative and Orthodontic dentistry can solve easily and conservatively, especially in young patients, many problematic cases and avoid time consuming treatment planning.*

►**Key–Words:** resin composites, shape alteration, orthodontic treatment, case report.

INTRODUCTION

Patients usually visit the dentist and frequently desire improvement in their smiles and it is up to the dentist to understand what is exactly bothering the patient in his smile, the color, shape or position of the teeth and always have in mind the minimum intervention of teeth. If the patient is complaining about the color of the teeth, bleaching is the most conservative option (Bello and Jarvis 1997).

If the patient is complaining about diastemas or about the shape of the teeth, the combination of orthodontic treatment and then improvement of tooth shape with resin composite, is the most conservative intervention for the treatment of these esthetic problems instead of porcelain laminate veneers or full ceramic crowns where healthy tooth structure will be removed. There is an attempt in bibliography to show combined cases with orthodontic and restorative procedures (Furuse et al. 2008, Miller 1995, Müssig et al. 2004, Willmot 2008).

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Fig. 1a,b. *Diastemas in front teeth and small shape of lateral incisors.*

Today's fine hybrid composite materials (nanohybrid, microhybrid, nanofill), offer increased abrasion resistance and colour stability. Modern composite materials have smaller particle size, higher amount of filler and mimic the dental hard tissue in both color and translucency (Nahsan et all. 2012, Dietschi et all. 1994). Dentinal shades provide enhanced opacity whereas enamel shades provide greater translucency. Additionally, in many composite formulations there are translucencies that can be used at the incisal surface (Nahsan et all. 2012).

The aim of this study is to present four clinical cases of young patients who required tooth modification before, to apply the chosen orthodontic treatment or after the orthodontic treatment for their esthetic improvement. All cases were restored, with emphasis given on the conservative management with resin composites.

For the management of these cases, photos and impressions were taken and diagnostic casts were created. Soon thereafter, diagnostic wax-up was produced and a silicon matrix was constructed in all cases to transfer the therapeutic scheme from the cast to the oral condition. After tooth preparation, resin was placed using the layering technique, to reproduce the appropriate shape and color of the tooth and finally the teeth were finished and polished.

CASES DESCRIPTION

Case 1

A young male patient of 14 years old, with no past medical history, was transferred from the orthodontic postgraduate clinic to the postgraduate clinic of operative dentistry, because he needed additionally operative treatment after the end of the orthodontic therapy. The patient needed shape alteration of his teeth due to the small shape of both lateral incisors which had created diastemas of anterior teeth (fig. 1a,b). He required to close diastemas not only for the aesthetic improvement of the anterior teeth but also in order to stabilize the final orthodontic result.

The normal function, form and esthetic results are adequately restored in direct procedures with composite resins (Nahsan et al. 2012). Resin composite is the ideal material in these cases, as it can provide very good esthetic results with minimal tissue removal (Müssig et al. 2004).

The insertion of resin as well as the different colors must be done with the incremental technique that allows separate restoration of enamel and dentin (Magne 2008, Nahsan et al. 2012). An important factor for the aesthetic outcome is the color of restoration. When selecting the color it has to be kept in mind that composites are darkened by the light curing process (Müssig et al. 2004). For this reason the direct color choice is the most appropriate way. That means the placement of small quantities of composite resin (enamel and dentin) to the intact surface of the adjacent tooth and then the polymerization, gives precise information for the choosing color to restore the tooth.

For the management of this case, photos and impressions were firstly taken and diagnostic casts were created. Soon thereafter, diagnostic wax-up was produced and a silicon matrix was constructed to transfer the therapeutic scheme from the cast to the oral condition (fig. 2).

After tooth preparation, a teflon tape was inserted at the adjacent teeth to protect these teeth from the etching process (fig. 3a,b). Initially right upper lateral incisor was restored. The resin at the incisal edge was placed with insertion of the silicon matrix/

Fig. 2. *Placement of the silicone Guide. Transfer from the wax-up the alteration of shapes of lateral incisors.*

guide and shape alteration of the upper lateral was transferred from the wax-up (fig. 3c). Then, using the layering technique the appropriate shape and color of the tooth right upper lateral incisor was reproduced (fig.3d).

The resin that was used was Miri's S1 for dentin and WR as enamel and Empress Direct trans 03 for transparency at the incisal edge. The Teflon tape was left without further use of a matrix and a wedge as that diastema was quite small. After right upper lateral incisor was restored the tape was removed and diastemas were closed at the first upper quadrant. Similarly, left upper lateral incisor, was restored as right lateral incisor with the same procedure and color. Finally both teeth were finished with a fine diamond bur and were polished with discs and silicon rubbers in a micromotor. For the final polishing initially a 3 micron diamond polishing paste was applied (Diamond paste A) and then 1 micron (Diamond paste B) using a special goat hair brush while in the end an aluminium oxide paste -Al_2O_3 (Shiny C-aluminium oxide paste) with a felt disk was applied (Enamel Plus shiny-HFO· fig 4a,b,c).

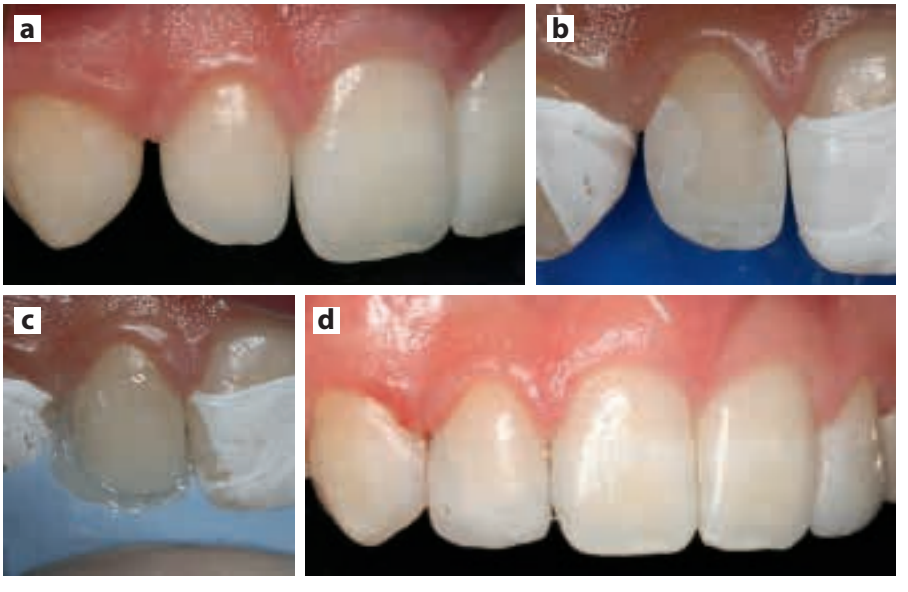

Fig. 3. a) *#12 diastema closure,* ***b)*** *placement of a Teflon tape at #11,13,* ***c)*** *placement of the silicone guide with resin composite,****d)*** *Final image of #12.*

Case 2

A young male patient of 16 years old, without past medical history, was transferred from the Orthodontic Postgraduate clinic to the postgraduate clinic of Operative Dentistry, because the patient at the end of the orthodontic therapy but before the removal of the orthodontic brackets, had an accident and fractured his central incisors. Central upper incisors were fractured (fig. 5). Immediately after the accident, the orthodontic mechanisms were removed and the fractures were restored with glass ionomer cement (fig. 6). After endodontic control tests on all his teeth, left upper central incisor was found to require endodontic therapy while other teeth remained alive and without any symptoms. After the removal of orthodontic brackets, white spots lesions were presented on all his front teeth and for that reason he was consulted to use beside the basic hygiene procedure (Bass technique and interdental cleaning) and tooth mouse paste for three weeks (a casein containing paste) for the remineralization of enamel. In regards to white spot lesions of the tooth surface after orthodontic treatment, it is a frequent phenomenon (Hadler-Olsen et al. 2012) with prevalence that varies from 4,9% to 84% (Gorelick et al. 1982, Mizrahi 1982, Tufekci et al. 2011, Nahsan et al. 2012) and can also be solved easily with resin infiltration techniques and if they

Fig. 4. a) *Initial image,* ***b)*** *The final image,* ***c)*** *The final patient's smile.*

Fig. 5. *Trauma of the upper central incisors at the end of the orthodontic treatment.*

Fig. 6. *Glass ionomer cement placement at #11, 21. White spots on the anterior teeth.*

persist composites materials can be used if these type of lesions create esthetic problem. After completion of the endodontic therapy he presented at the operative dentistry department. The patient didn't follow hygiene instructions so the spots were progressed and he needed restorations. Then, restorations of cervical lesions of upper lateral and central incisors and restorations of fractures of his central incisors were performed (fig. 7).

For the management of this case, photos and impressions were taken prior to the procedure and diagnostic casts were created as before. Diagnostic wax-up was produced and a silicon matrix was constructed to transfer the therapeutic scheme to the oral condition. After tooth preparation, caries lesions were removed. The resin was placed with insertion of the silicon matrix/guide and shape alteration of central and lateral upper incisors was transferred from the wax- up (fig. 8a,b,c,d,e). Then, using the layering technique to reproduce the appropriate shape and color of the teeth, upper incisors were restored (fig. 9a,b,c). The resin that was used was HFO UD3,5 and HRI UD3 for dentin and HRI UE2 for enamel. Finally teeth were finished and polished.

Case 3

A 16 years old female patient was referred to the postgraduate clinic of operative Dentistry before the beginning of the orthodontic treatment for the restoration of her anterior teeth. At the upper front teeth, small peg lateral patient's teeth created difficulties to the orthodontist to bond and orientate the brackets at these small teeth (fig. 10a,b). Also, at the lower front teeth she had deciduous central incisors and congenital absence of permanent lower central incisors respectively (fig.10c,d). An abnormal tooth shape, like small/peg lateral incisors or irregular position

Fig. 7. *The lesions of the anterior teeth 20 days later, due to poor oral hygiene.*

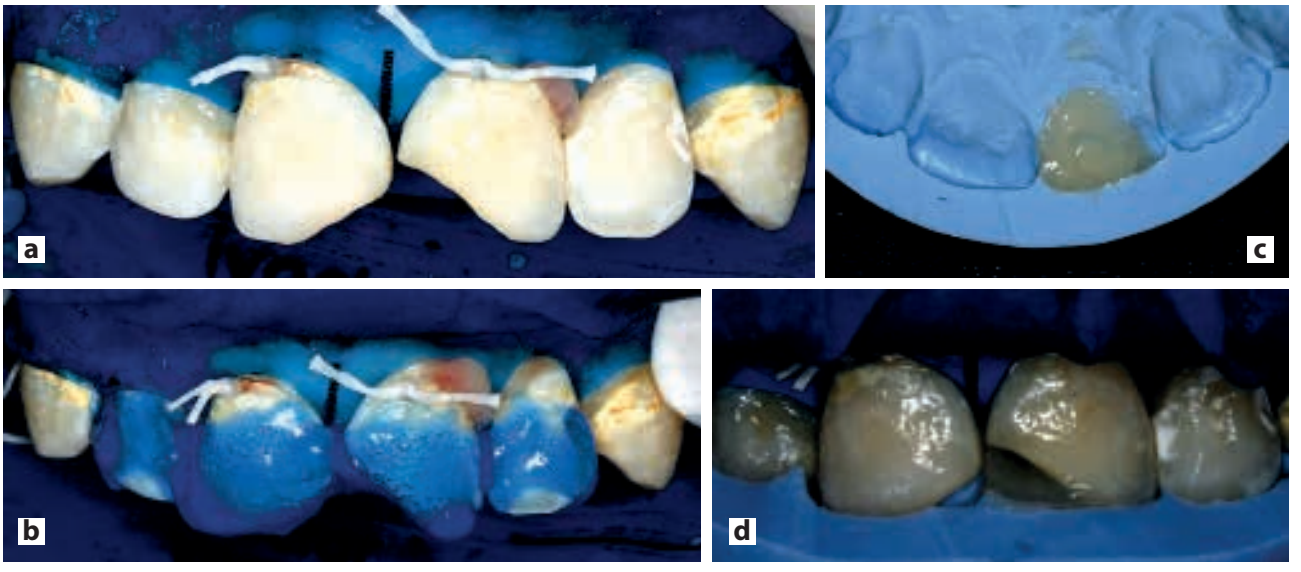

***Fig. 8. a**) Caries removal, **b)** Etching of anterior teeth, **c)** Resin composite placement in silicone guide, **d)** Placement of resin composite at # 21 with the aid of the silicone guide, **e)** formation of palatal surface.*

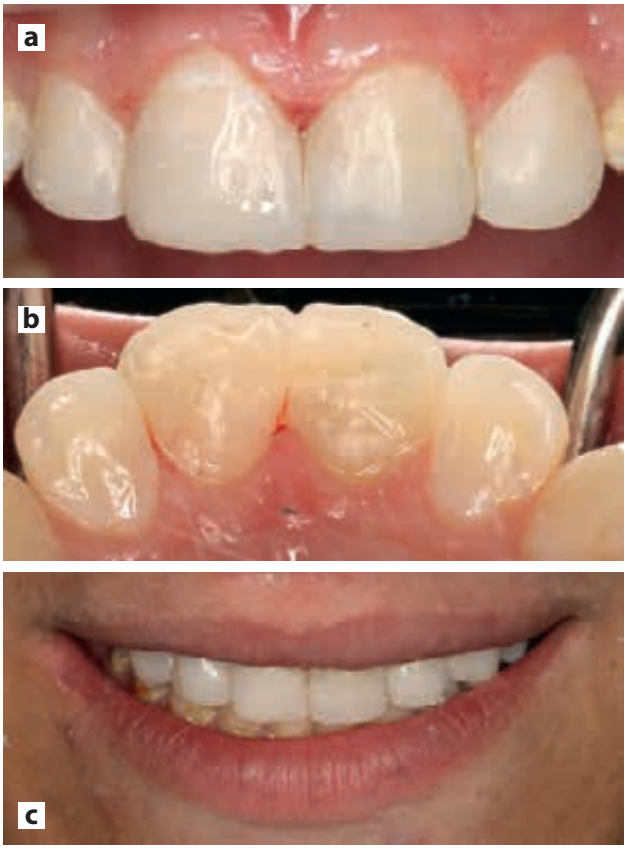

***Fig. 9. a)** Final image of front teeth immediately after, buccal view, **b)** Palatal view, **c)** The patient's smile after final polishing of the restorations.*

(diastemas, rotated teeth) may result from developmental or pathological factors (Chu et al. 2001, Izgi and Ayna 2005, Wolff et al. 2010). Anomalies in the tooth formation process during initiation or proliferation of the tooth bud cause hypodontia (Izgi and Ayna 2005). Peg-shaped maxillary lateral incisors is the most common developmental malformation of teeth and their incidence was found to be 0.4%-0.8% (Backman and Wahlin 2001, Chattopadhyay and Srinivas 1996).

After orthodontic therapy the final treatment plan for the absence of her lower incisors was the placement of an implant with a cantilever. For the lower incisors orthodontist proposed to restore them at a physical size of permanent teeth for the esthetic improvement while maintaining of the diastema until the end of the orthodontic therapy. For the upper lateral incisors the orthodontist proposed to enlarge only the height of the peg lateral without changing teeth deviation and their width as in this way he would be able to achieve esthetic improvement of the anterior teeth and easier bonding of the bracket. After orthodontic therapy the therapeutic choices for the re-establishment of upper anterior teeth were: direct veneers with resin composite or indirect porcelain laminate veneers. After diagnostic wax-up a

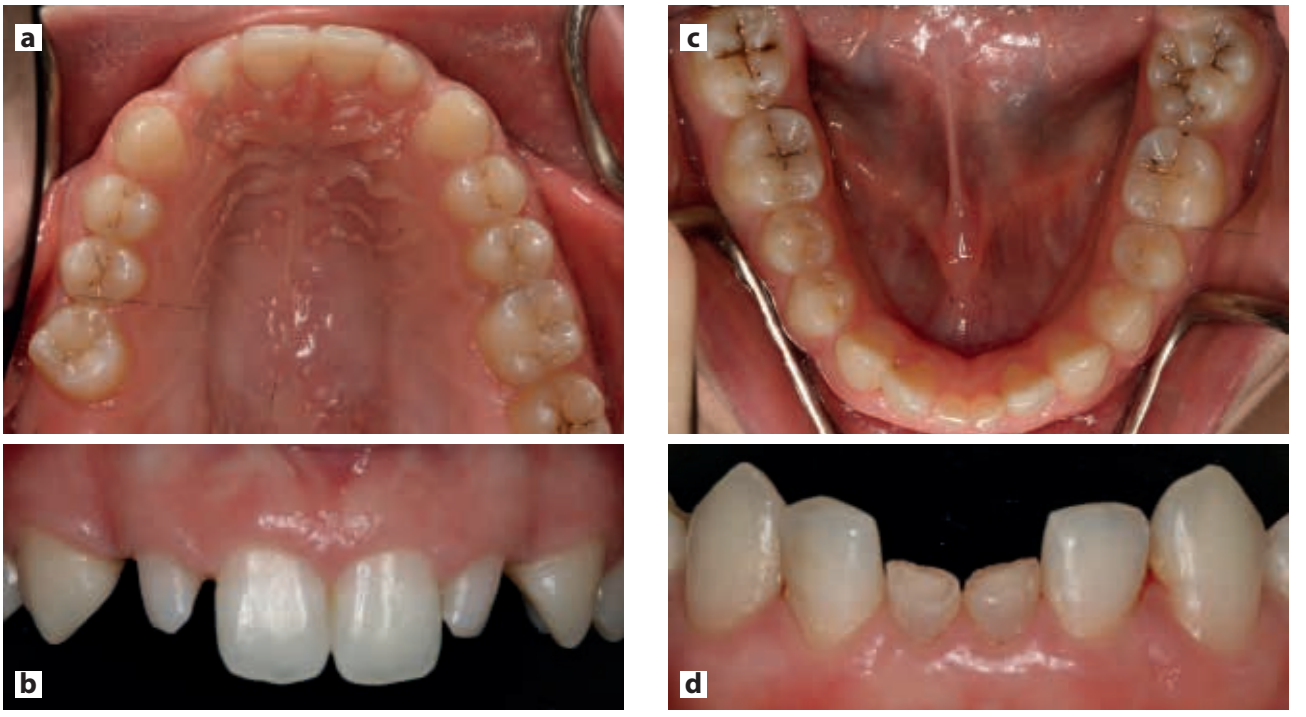

Fig. 10. a) *Initial image of upper jaw with peg lateral incisors* ***b)*** *Initial image of peg lateral,* ***c)*** *lower arch with deciduous central incisors,* ***d)*** *Initial image of deciduous central incisors.*

silicon indice was fabricated to transfer the therapeutic scheme from the cast to the oral condition. After minimal tooth preparation with a fine diamond bur, the resin was placed with the insertion of the silicon guide and shape alteration of upper lateral incisors was transferred from the wax-up (fig. 11a). The resin that was used was Miri's S1 for dentin and WR as enamel. The same procedure was performed for the lower deciduous teeth. Then, using the layering technique to reproduce the appropriate shape and color of the tooth and with the aid of wedges and matrices upper lateral incisors (fig. 11b,c) and similarly deciduous lower central incisors (fig. 12a,b), where finally restored (fig. 12c,d). Finally teeth were finished and polished.

Case 4

An orthodontic 18 years old male patient with congenital absence of lateral incisors needed esthetic improvement of his anterior teeth (fig. 13). Before recontouring of teeth esthetic aspects related to proportions, smile analysis (McLaren 2009), shape and color have to be considered. Proportions like "golden proportion" or the RED (recurring esthetic dental) proportion can be used in these cases (Baratieri et al. 1998) . Golden proportion 1:1.618, states that the maxillary lateral incisor should be 62% of the width of the maxillary central incisor, and the width of the maxillary canine should be 62% of the width of the resulting lateral Incisor. The RED proportion states that the proportion of the successive widths of the maxillary teeth as viewed from the front should remain constant, progressing distally. When using the 70% RED proportion, the width of the maxillary lateral incisor is 70% of the frontal view width of the maxillary central incisor, and the maxillary canine is 70% of the width of the resulting lateral incisor (Blitz 1996, Ward 2007). Initial images of anterior teeth and smile were taken (fig. 14a,b) and diagnostic casts were created. After the completion of the wax-up (fig. 15), a silicon index was created to transfer shape alteration of central incisors, canines and premolars on the oral condition.

Shape alteration of canines was performed at these teeth as before with resin composite and following the diagnostic wax-up. Additionaly resin was placed distally of both upper central incisors and mesial of upper first premolars. Upper premolars were altered to look like upper canines and canines to seem like lateral incisors (fig. 16a,b). The resin composite that was used was HFO, a medium flow microhybrid resin, and was used with layering technique so for enamel UE2 was used and for dentin UD2 and UD3 were used.

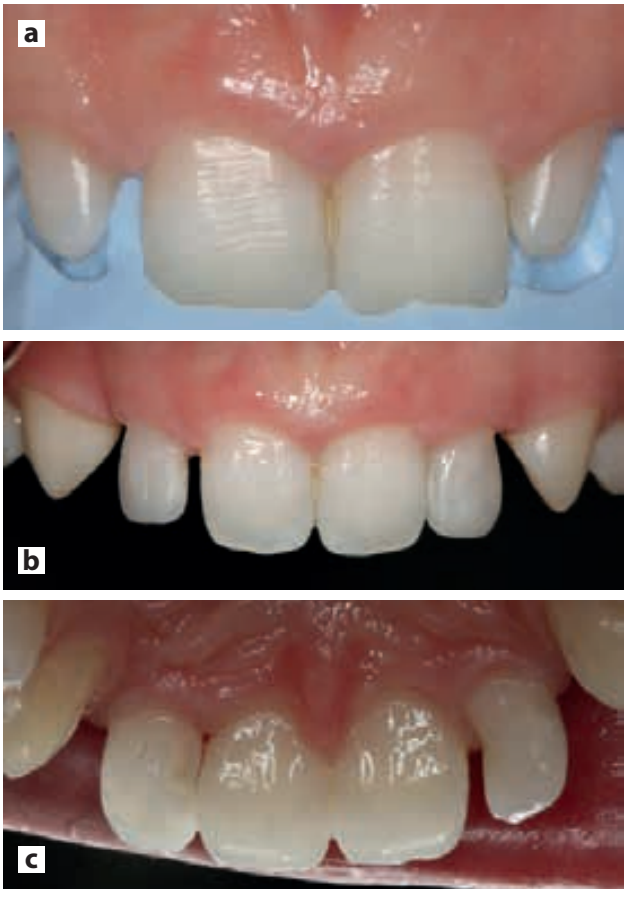

Fig. 11. a) *Placement of the silicone guide,* ***b)*** *Shape alteration of peg lateral before orthodontic treatment buccal,* ***c)*** *and palatal view.*

DISCUSSION

Many different cases can be managed with the collaboration of orthodontic and operative dentistry. The use of resin composites besides the orthodontic therapy helps clinician to avoid time consuming and complex treatment planning. The survival rate of tooth coloured restorations for tooth shape alteration is around 80%-89%. Peumans et al found an 89% survival rate after 5 years of clinical service. Reasons of replacement were mainly the loss of anatomical form and to a lesser degree a severe color mismatch (Peumans et al. 1997, Peumans et al. 1997). In a more recent study, Wolff et al. (2010) found an 80% survival rate ; main reason of failure of these restorations were material fractures (resin fractures or chipping 60%) and events such color changes (14%) or marginal gaps (12%) were less responsible for failures.

In contemporary literature there are many references of clinical cases on restorations of esthetic problems (shape alteration, closing interproximal diastemas, direct composite resin veneers) with modern materials and very well direct results (Ardu and

Fig. 13. *Orthodontic patient with missing lateral incisors.*

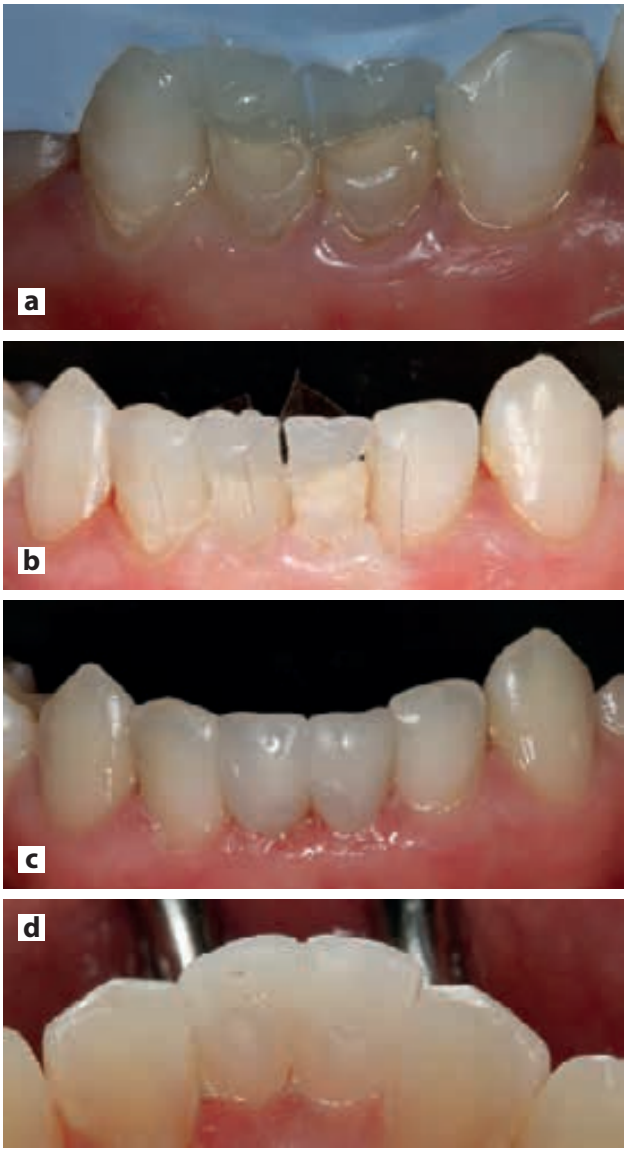

Fig. 12. a) *Composite resin (palatal enamel) placement with the aid of the silicone guide,* ***b)*** *Matrices placement to achieve the contact points,* ***c)*** *Final image immediately after polishing buccal view* ***d)*** *palatal view.*

Fig. 14. a) *Initial image of anterior teeth,* ***b)*** *Initial patient's smile.*

Krejci 2006, Bagis et al. 2008, Griffin 2007, Koczarski 2008). Unfortunately there are no long-term clinical studies on the behaviour of these restorations.

This type of restorations is more comparable with the class IV restorations indicate a median survival 4-5 years (Peumans et al. 1997). The success rate of class IV restoration varies between 73% survival in 8 years (Millar et al. 1997), and more recent studies revealed 82% survival at 10 years (9.1 years survival average) and only 27.3% fractures of restorations in 14 years (van Dijken and Pallesen 2010). These restorations are even comparable with alternative treatments such as porcelain laminate veneers· success of 90% in ten years (Peumans et al. 2000).

CONCLUSIONS

The use of resin composites is a minimally invasive treatment strategy that allows the conservative re-establishment of aesthetics of the anterior teeth and smile before but mainly after completion of orthodontic treatment, and at the same time is avoiding time consuming and complex treatment planning.

Clinical significance:

Cases like these that were mentioned above can be managed easily with the collaboration of orthodontic and operative dentistry.

Fig. 15. *Shapes alteration of central incisors, canines and premolars.*

Fig. 16. a) *Final image of anterior teeth after the restoration with resin composite.* ***b)*** *Final patient smile.*

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Pseudo-Class III malocclusion: a functional displacement of the mandible due to abnormal tooth contact. Review and case reports.

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SUMMARY

Retroclination of maxillary incisors can cause a more anterior posture of the mandible due to insical interference, a condition called pseudo-Class III malocclusion. In the diagnosis and treatment planning of Class III malocclusions, a distinction must be made between pseudo and true Class III skeletal patterns. As etiology of Class III malocclusion is genetic and environmental, early treatment of pseudo-Class III malocclusion and treatment of anterior cross bite can prevent the decrease of the maxillary growth and the development of a real skeletal Class III pattern. The optimal time to initiate treatment as well as the way of treatment is an important consideration. This paper presents the diagnostic criteria for pseudo-Class III malocclusion to differentiate from skeletal Class III malocclusion. The clinical treatment of three patients is also presented before and after short term therapy.

►**Key–Words:** pseudo-Class III, functional displacement, mandible..

INTRODUCTION

Pseudo-Class III malocclusion has been characterized by an anterior cross bite in the presence of a forward mandibular displacement (Moyers 1988, McNamara 1994, Rakosi 1997, Rabie and Gu 2000). Anterior positioning of the mandible may be the result of abnormal tooth contact that forces the mandible forward. The maxillary anterior teeth take a lingual position in relationship to the mandibular anterior teeth causing an anterior cross bite. Patients who present with a forward shift in the mandible may have a Class I skeletal pattern, normal facial profile and a Class I molar relation in centric relation (CR), but Class III skeletal and dental pattern in centric occlusion (CO), a situation referred as pseudo Class III malocclusion (Ngan 1997).

The criteria for pseudo class III malocclusion are ill-defined and the dentoskeletal characteristics, especially in the mixed dentition are unclear (Ngan 1997). Tweed (1996) classified Class III malocclusion into 2 categories: Category A and Category B, where category A was defined as pseudo-Class III malocclusion with a conventional shape mandible (Tweed 1996). Moyers (1988) suggested pseudo-Class III malocclusion as a positional malrelationship with an aquired-neuro-muscular reflex (Moyers 1988). Pseudo-Class III malocclusion has been identified with anterior cross bite as a result of mandibular displacement.

Premature contact between the maxillary and mandibular incisors results in forward displacement so as to disengage the incisors and permit further closure into the position that the posterior teeth occluded. Turley (1993) and Lin (1985) showed some degree of hereditary tendency while Rabie and Gu

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(1999) showed no family history in the majority of their sample (Rabie and Gu 1999). The incidence of pseudo Class III malocclusion in a sample of 7096 Chinese children was about 2-3% which is one and a half times that of skeletal Class III malocclusion in the same population (Lin 1985). The purpose of this study is to present the diagnostic criteria for the pseudo-Class III malocclusion in order to familiarize the practicing clinician with the different diagnosis from skeletal class III malocclusion and to highlight the advantages of early intervention and treatment.

SKELETAL CHARACTERISTICS

Rabie and Gu (1999) studied the skeletal characteristics of pseudo Class III malocclusion based on the cephalometric analysis (fig. 1) of a sample of 36 patients (Rabie and Gu 1999). They compare their sample with a group with Class I malocclusion and their results were about the same with Gu (2002) who underwent a similar study 2 years later (Gu 2002):

- A significantly decreased midfase length in the pseudo Class III group
- A significant decrease in the size of the maxilla in the pseudo Class III group as a result of the anterior cross bite which lead to restraining of the maxillary growth
- A forward mandibular position in the pseudo Class III group with a highly significant difference compared with the Class I malocclusion group. This result was expected as all the cases included in pseydo Class III group showed anterior cross bite and anterior displacement of the mandible.
- No significant difference in the mean value of mandibular length (Co-Gn) between the two groups. In contrast the mandibular length (Co-Gn) is of a high importance for the differential diagnosis from skeletal Class III , as Co-Gn is 3-6 mm longer in skeletal Class maloclussion than that in Class I malocclusion.

DENTAL CHARACTERISTICS

Results of previous (Ngan 1997, Sharma and Brown 1968, Thilander 1985, Graber 1997) studies demonstrate that in pseudo Class III malocclusion upper incisors are retroclined whereas lower incisors are normal in contrast with the dental features of a skeletal Class III malocclusion where the maxillary incisors are protrusive and the madibular incisors retrusive (Ngan 1997, Sharma and Brown 1968, Thilander 1985, Graber 1997). The retroclined upper incisors lead to dental interference, mandibular displacement and anterior cross bite. The most important characteristic is that molar relationship is Class I at CR and Class III at CO. In contrast Lee (1978) pointed out that in pseudo Class III malocclusion molars show a Class I relationship in CO also.

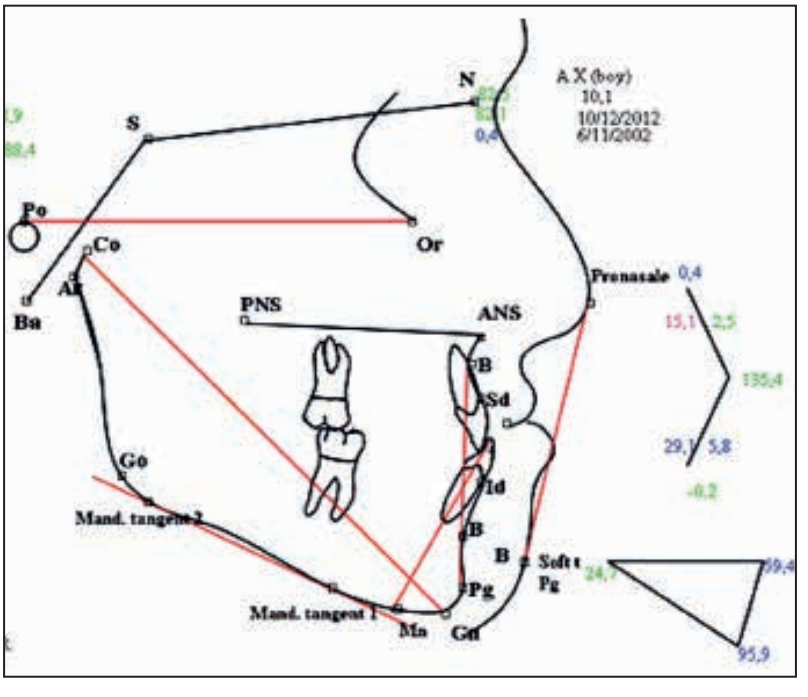

Fig. 1. *Reference points and lines used in cephalometric analysis (Rabie and Gu 2000).*

DIFFERENTIAL DIAGNOSIS FROM SKELETAL CLASS III MALOCCLUSION

The severity of Class III malocclusions ranges from dentoalveolar problems with anterior posturing of the mandible to true skeletal problems with significant maxillomandibular discrepancies (Ngan 2006). In addition, the condition could be complicated by vertical growth problems. A systematic way to diagnose Class III malocclusion can help in identifying patients who might respond favorably to early treatment.

A differential diagnosis of patients with pseudo or true skeletal Class III malocclusions should include family history of Class III malocclusion, dental assessment of molar and incisal relationships, functional assessment to determine the presence of a CO or CR

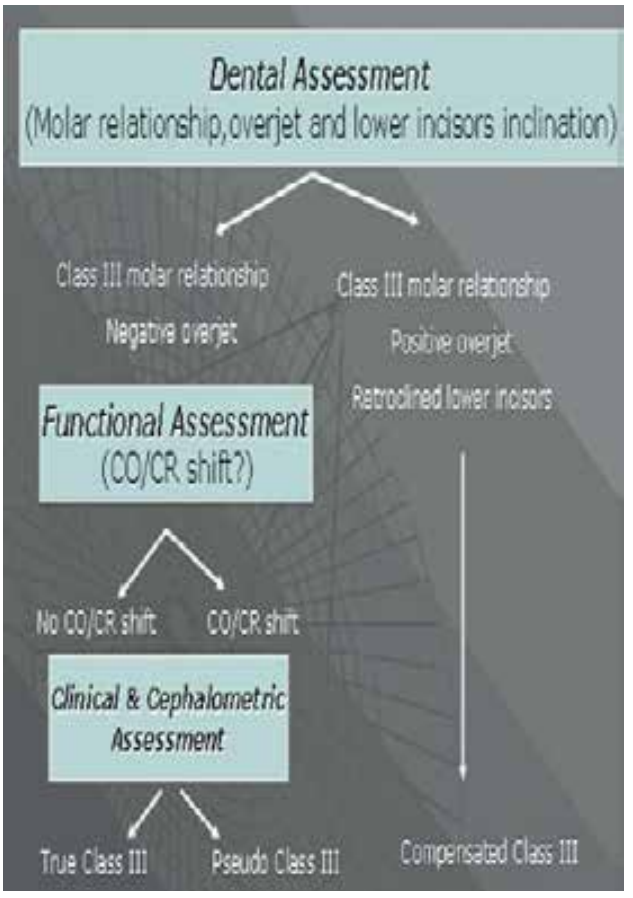

Fig 2. *Diagnostic scheme to differentiate pseudo-Class III patients from true skeletal Class III patients (Ngan 1997).*

shift on mandibular closure, cephalometric analysis to determine the anteroposterior discrepancy of the maxilla relative to the mandible.

For the *dental assessment*, the Class III molar relationship must be checked if it is accompanied by a negative overjet. A positive overjet or end-to-end incisal relationship together with retroclined mandibular incisors usually signifies a compensated Class III malocclusion.

For the *functional assessment*, it must be checked if a centric relation (CR) or centric occlusion (CO) discrepancy exists. Anterior positioning of the mandible can result from an abnormal tooth contact that forces the mandible forward, leading to a pseudo Class III malocclusion. Elimination of the CO or CR discrepancy should show whether it is a simple Class I malocclusion or a compensated Class III malocclusion (Ngan 2006).

As a general rule, if a patient with anterior cross bite cannot make contact of the upper and lower incisors on closure, it is obvious that there is a real skeltal Class III malocclusion.

THE IMPORTANCE OF EARLY TREATMENT

As the etiology of Class III malocclusion can be genetic or environmental (Ngan et al. 1997), early treatment of pseudo-Class III can help to minimize the adaptations and limitations that are often seen in severe malocclusion of the late adolescence. Anterior cross bite should be corrected once recognized to allow for normal dental base development and subsequent favorable skeletal growth.

The objective of early treatment is to create a more favorable environment for future dentofacial development. Interceptive treatment can reduce the amount of dental compensations to skeletal discrepancy that is often associated with a more severe malocclusion in late adolescence (Joondepf 1993). Delaying the treatment until the permanent dentition may also cause loss of space required for the eruption of the canines (Lee 1978, Sharma and Brown 1968).

This lack of space could be caused by the retroclination of upper incisors which characterizes pseudo Class III malocclusions. Therefore, a growing number of clinicians believe in the advantages of early intervention (Rakosi 1997, Turley 1993, Moyers 1988). A 4-year follow-up in cases treated in the early mixed dentition showed settling of the occlusion, no relapse of the anterior cross bite and eruption of the permanent teeth into Class I relationship at the proper mandibular position (Rabie and Gu 1999).

Various appliances have been devised for early treatment of a pseudo Class III, such as removable plates with springs, fixed or removable inclined planes, functional appliances, chin-cups, and simple fixed appliances (Proffit 2000, Major and Glover 1992, Hagg et al. 2004). One popular type of simple fixed appliance is the 2 by 4 appliance, which is composed of bands on the first permanent maxillary molars, brackets on the maxillary incisors, and a wire with advancing loops (Proffit 2000).

At least two studies (Degushi et al. 1999, Lertpitayakun et al. 2001) have reported that self-correction of anterior cross bite during the transition from primary to early mixed dentition was potentially high. This seems to indicate that very early treatment of anterior cross bite should be implemented with great caution to avoid unnecessary clinical procedures.

CASE REPORT 1

A boy of 11.10 years old, seek for orthodontic treatment at the Orthodontic clinic of University of Athens with chief complain "my teeth does not close properly". Skeletal characteristics as showed in lateral

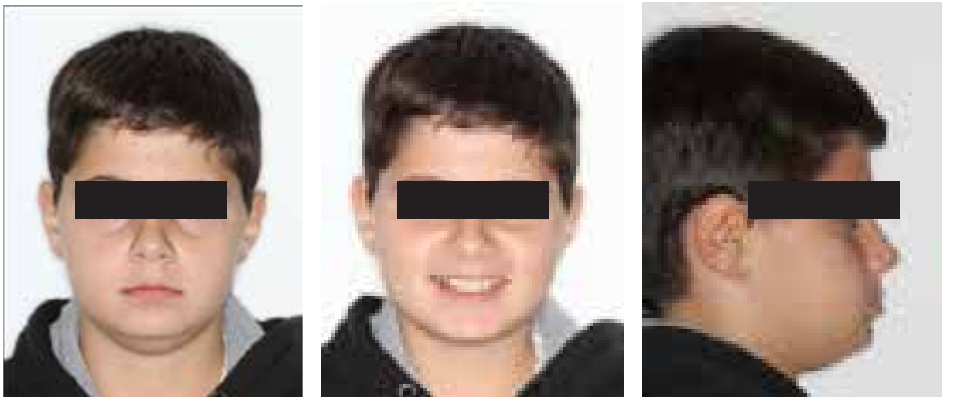

Fig. 3. *11.10 years old boy, with contacts at the incisors, forward displacemant of the mandible.*

cephalometric radiograph in central relation were Class I jaw relationship in sagittal plane and normal jaw relationship in vertical plane. Dental characteristics in CR were Class I molar relationship, retroclined upper incisors but with proper position into their apical base. Lower incisors were proclined and protruded. Occlusion at the anterior teeth in CR, were edge to edge with dental contacts between 11 to 41 and 21 to 31, and a lateral open bite at the posterior teeth.

Patient in order to accomplish maximum interdigitation was forced to slide the mandible forward. As a result, patient presented anterior cross bite, negative overjet and Class III molar relationship (fig. 3) The patient was treated with fixed appliances. The aim was to correct the inclinations of the upper and lower incisors, in order to eliminate the contact which dislocates the mandible forward in CO. Duration of orthodontic treatment, to reach a positive overjet was 7 months (fig. 4) and the full treatment lasted 19 months (fig. 5).

CASE REPORT 2

A 12.1 years old girl was treated at the same Orthodontic clinic of University of Athens. Skeletal characteristics as showed in lateral cephalometric radiograph revealed a Class III tendency in sagittal plane, normal jaw relationship in vertical plane and constricted maxilla in horizontal plane. Dental characteristics in CR were Class I molar relationship, retroclined and with normal position upper incisors into their apical base unlike lower incisors which presented normal inclination and position. Occlusion at the anterior teeth in CR, were edge to edge with dental contacts between 21 and 31, and a lateral open bite at the posterior teeth at both sides. Patient was forced to slide the mandible forward 2 mm in CO and presented anterior cross bite, negative overjet and Class III molar relationship (fig. 6).

Fig. 5 Final treatment records.

Fig. 4. *After 7 months with fixed appliances, positive overjet is achieved.*

Fig. 5. *Final treatment records.*

Treatment included orthopedic devices such as Hyrax, Delaire mask and fixed appliances (fig. 7). The aim was to correct the constricted maxilla and to affect its growth to a forward direction. Also, to correct inclinations of the upper incisors, in order to eliminate the contact. Duration of active treatment and retention phase with Hyrax and Delaire mask was 4 months and continued with fixed appliances in order to achieve a positive overjet 3months later (fig. 8).

CASE REPORT 3

A 9 years old girl seeks orthodontic treatment, to correct her teeth which had "a slight crowding". Skeletal characteristics revealed a Class III tendency in sagittal plane and hyperdivergent jaw relationship in vertical plane. Dental characteristics in CR were Class I molar relationship, retroclined and retruded upper incisors and proclined lower incisors. Occlusion of the incisors in CR, was edge to edge with dental contacts between 21 to 31and 32, and a lateral

Fig. 6. *12.1 years old girl with contact between 21 and 31 in CR. In CO forward movement of the mandible, resulting in anterior and posterior crossbite.*

open bite at the posterior teeth at both sides. Forward slide of the mandible, anterior and posterior cross bite, negative overjet and Class III molar relationship showed in CO (fig. 9).

Fig. 8. *After 7 months of orthopedic and orthodontic treatment. Positive overjet is achieved.*

Fig. 7. *Hyrax appliance, for maxillary expansion.*

Fig. 9. *9.9 year old girl with a contact between 21-32 and 31in CR. Forward movement of the mandible in CO resulting in anterior and posterior crossbite.*

Treatment started with orthopedic devices Quadhelix and Delaire mask.(fig. 10). Fixed appliances were also bonded with the scheme 2×4 (braces only to the upper incisors connected to bands at the first upper molars) and continued with full fixed appliances.

The aim was to correct inclinations of the incisors, in order to cease contact which caused forward movement of the mandible in CO. Duration of treatment until a positive overjet was accomplished was 6.5 months. (fig. 11).

Fig. 10. *Quadhelix appliance.*

CONCLUSIONS

Diagnostic characteristics of pseudo Class III malocclusion could be summarized as:

- Majority show no family history.
- Negative overget and anterior cross bite.
- Mandibular forward displacement due to primary tooth contact.
- Class III molar and canine relationship in CO and Class I in CR.
- Retroclined upper incisors and normal lower incisors.
- Decreased midface length.
- Normal mandibular length.

The differential diagnosis from true skeletal Class III malocclusion is of great importance as the timing and the way of treatment are totally different.

Early orthodontic intervention for pseudo Class III malocclusion should be initiated to prevent existing problems from getting worse and minimize or eliminate the need for comprehensive orthodontic treatment at a later stage.

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Fig. 11. *6.5 months after orthopedic and orthodontic treatment with a positive overjet.*

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Cone-Beam Computed Tomography (CBCT) in General Dentistry –A Review of literature.

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SUMMARY

In clinical dental practice, certain information cannot be taken through clinical examination and this is why radiographs are necessary. However, conventional two-dimensional display of three-dimensional structures of the oral cavity may offer unclear or insufficient information. Thanks to the development of technology, Dentistry has today, a modern diagnostic imaging tool, based on the operating principles of CT, called Cone Beam Computed Tomography (CBCT).

Cone beam computed tomography (CBCT) is a promising technique that enables imaging of maxillofacial structures existing in three planes (sagittal, vertical and transverse), while providing the ability to process and reconstruct the information that these structures contain. It can be very helpful for the clinician if it is utilised when information given are useful or even necessary.

The purpose of this paper is to briefly present the technology of CBCT and to analyse the application of this technology in multiple fields of clinical dentistry, as mentioned in the international litterature of the last few years.

►**Λέξεις–Κλειδιά:** CBCT, 3D imaging, computed tomography.

INTRODUCTION

Since 1896 when the "patriarch" of Endodontics Friedrich Otto Walkhoff held the first dental radiograph (two weeks after the publication of Wilhelm Röedgen concerning the discovery of X-rays), that illustration has since been an indispensable tool in the hands of the dentist.(Rezai and Salamat 1985). Three years later, in 1899, Kells uses this technological development by making the first intra-oral radiograph to determine working length of the canal in a central maxillary incisor, in which he had placed a lead wire (Langland and Langais 1995). Until today, this kind of imaging, despite its limitations, is the only easily accessible source of clinical information for the outer contour of all subgingival structures and the morphology of pulp cavity.

The next evolution in dental radiology was the panoramic film introduced in dentistry, in 1934, by Hisadugu Numata until the period of 1946 to 1958 when Yrjo Veli Paatero developed the technique in the format which is presently used. Despite the larger field of view, the poor resolution leads to limited diagnostic reliability for endodontic applications (Angelopoulos 2001).

Today, almost a century later, because of the development of science, especially of tomographic images, digital radiography and computer analysis and processing of data, Dentistry has a modern diagnostic imaging tool, the Cone Beam Computed Tomography (CBCT).

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RADIOGRAPHIC IMAGING IN DENTISTRY– LIMITATIONS OF CONVENTIONAL RADIOGRAPHY

In clinical dental practice, certain information cannot be taken through clinical examination and this is why radiographs are necessary. Such information may refer to pathological conditions of teeth, periodontium and jaws.

In particular, intra-oral periapical radiographs and bitewings x-ray films can assist in checking: caries, fractures, presence of pulp stones, intense calculus deposition, dental absorption – assisting in the diagnose of internal or external absorption, abnormalities in teeth formation, periodontal pathology, periapical lesions assessment of previous root canal treatments, prostheses and fillings as well as determination of canal length (Angelopoulos 2001).

Panoramic radiograph, imaging most of the maxillofacial area, can give information concerning the situation of the bone in the oral cavity during the mixed dentition, abnormalities in the number, conformation and tooth eruption, diagnosis of maxillofacial anomalies and planning of surgical treatment, pathological changes in the bones of the jaws, temporomandibular joint problems, possible bone fractures, implants and particularly about the vertical dimension of the alveolar bone, partial or total edentulism before planning prosthetic restorations (Angelopoulos 2001).

However, conventional two-dimensional display of three-dimensional structures of the oral cavity causes deformation and/or errors in the imaging, due to either the geometry of the structures, or in the overlap of different density structures. Magnification of the final image is usual, as well as the existence of artificial or "imaginary" structures (mostly in the panoramic radiograph). Finally, it cannot be easily assessed if normal or pathological structures are localized buccally or lingually, because of the expected overlap of anatomical structures. The result is an unclear image that requires experience for proper interpretation (Goldman et al. 1972, Walker et al. 2009).

Cone beam computed tomography (CBCT) is a promising technique that enables imaging of maxillofacial structures in three planes (sagittal, vertical and transverse), and provides the ability to process and reconstruct the information that these structures contain.

CBCT – HISTORY AND FUNCTION

Cone beam computed tomography (CBCT), although considered an innovation in the field of dentistry, has already made a long-term evolution, beginning with the computerized tomography in 1967 and the first computer scanner installed in Atkinson Morley Hospital, in London, in October 1971 (Tsiklakis 1998). CBCT (also known as volumetric CT-Volumetric Computerized Tomography, VCT) is a relatively new diagnostic method, introduced in 1997. The operating principle of the system differs from medical tomographers, mainly because it does not require taking initial images of saggital sections for further reconstruction of the image. These sections are created digitally by the computer system, after processing of the digital image of the radiated object (Zatz 1981)

At this point it should be noted that both conventional and computed tomography imaging is important in the diagnosis and treatment of dental and maxillofacial problems. Computed tomography is used for three-dimensional reconstruction of an image providing better quality, but with a higher radiation dose. CBCT can be the solution to this problem, providing excellent image quality in combination with minimum absorbed dose of radiation.

Cone beam computed tomography uses a conical radiation beam and the lamp system - sensor performs a full turn of 360 º around the patient's head (Davison 1982, Tsiklakis 1998, Kandarakis 2000). In the rotational movement a series of radiation-X emissions is produced (typically one at a time, per degree of rotation), in order to display the original digital image at a computer screen (Tsiklakis 1998). This rotational movement produces the original data called raw data, shown as side tomography slices and used to reconstruct the original image (Kandarakis 2000). The scanning system of CBCT consists of a high kilovoltage lamp (110 kv) and a plane sensor (512 × 512 pixels) linked with the edge of the lamp (Zatz 1981).

Image data can be collected for a complete maxillofacial volume (10-15mm) or limited regional area of interest (up to 5mm). The dimensions of the scan field (known in the literature as FOV –Field of View), vary among different machines and some machines can modify their FOV, as much as the shape and size of detector and geometric design and orientation of the beam allow it. Generally, smaller FOV gives images of greater resolution. In endodontics, FOV can correspond to a single tooth, while the suggested resolution is 0.3mm minimum.(Liedke et al. 2009).

Resolution for CBCT scanners for dental use varies between 0.076 mm-0.4 mm. Most of these scanners allow changes related to the scanning time (usu-

ally between 5,7 sec to 40 sec). Respectively, radiation dose varies between 40 to 135 mSv depending on parameters such as those related to the image (kVp, mAs), the use of continuous or pulse beam, the type of filter used and the dimensions of the FOV. The smaller the FOV is (usually it is determined by the clinician according to the needs of each case), the lower the radiation dose for the patient (Ludlow and Ivanovic 2008, Schulze et al. 2004).

Data collected during CBCT scanning is presented initially on a computer screen and it can be processed and adapted to real dimensions without distortion. Special software allows the dentist to make accurate calculations.

CBCT IN DENTISTRY

CBCT has been used and it is suggested to be used in many fields of dentistry:

Oral and Maxillofacial Surgery

In maxillofacial surgery, the use of CBCT can assist in the easier and safer extraction of impacted third molars and canines, imaging root orientation more accurately or the relationship between roots and the sinus or the inferior alveolar canal (Heurich et al. 2002, Nakagawa et al. 2002, Danforth et al. 2003, Friedland et al. 2008, Chien et al. 2009). In a survey to assess the sensitivity of CBCT in identifying the inferior alveolar nerve and assessing the possibility of its exposure during surgical extraction of third molars, it was proven significantly better than panoramic radiography (Tantanapornkul et al. 2007).

A frequent concern with regard to the mandible is the existence of a bifid inferior alveolar nerve, which has been estimated to 1% of the population-based on the study of panoramic radiographs. However, studies in more than 100 patients with CBCT technology showed that this anatomical variation is detected in 65% of the patients (Naitoh et al. 2009).

Bone lesions of inflammatory or neoplastic etiology are common findings among dental patients and may be combined with symptoms and / or clinical signs or be found randomly in a radiographic examination. In the international literature of the last few years, there are several case reports using the technology of CBCT for such lesions (Rozylo-Kalinowska and Rozylo 2001, Nakagawa et al. 2002, Ziegler et al. 2002, Araki et al. 2006, Schulze et al. 2006, Araki et al. 2007, Closmann and Schmidt 2007, Fullmer et al. 2007, Harokopakis-Hajishengallis and Tiwana 2007, Kumar et al. 2007, Smith et al. 2007, Abdelkarim et al. 2008, Guttenberg 2008, Quereshy et al. 2008, Rodrigues and Estrela 2008, Barragan-Adjemian et al. 2009, Kamel et al. 2009). Apart from the case reports, researches have been published to evaluate the diagnostic accuracy of CBCT compared to the panoramic x-rays in cases of extensive bone damage. Specifically, Momin et al. (2009) compared the accuracy of these two technologies in the evaluation of tumors on mandibular gums and evaluated the results based on histopathological findings after biopsy. CBCT was found to be superior in sensitivity, but specificity between the two had no statistically significant difference. In a similar survey of Hendrikx et al. (2010) CBCT seemed to be superior in sensitivity and specificity than panoramic radiography and magnetic resonance imaging.

Oral surgeons usually have to treat wounds and fractures in the oral-maxillo-facial area. It is a general rule that CBCT can be particularly useful when conventional radiographs are not sufficient to study the type of fracture or the degree of displacement of the fractured parts, especially in the tubers. (Schoen et al., 2008) Several case reports in the literature underline the usefulness of CBCT in the study of fractures of the mandible (Ziegler et al. 2002), the intraoperative imaging of the fractures (Heiland et al. 2004a, Scarfe 2005, Pohlenz et al. 2007, Pohlenz et al. 2008), the study of fractures of the zygomatic arch (Heiland et al. 2004a, Pohlenz et al. 2007) and their postoperative evaluation (Heiland et al. 2004b).

Implant dentistry

In order to choose the appropriate size and length of an implant the dentist should know the amount of bone and the extent of edentulous area, the morphology and thickness of the alveolar ridge and the exact location of both, the inferior alveolar nerve canal (for the mandible) and the proximity of other anatomical structures (such as the sinus for the maxilla) (Hatcher et al. 2003, Kobayashi et al. 2004, Lascala et al. 2004, Marmulla et al. 2005, Ludlow et al. 2007, Loubele et al. 2008). CBCT offers a more accurate and reliable imaging giving the opportunity for a better preoperative planning. In particular, CBCT can accurately identify the length, width and curvature of the inferior alveolar nerve, artery and vein in the area between the mental foramena (Uchida et al. 2009, Angelopoulos et al. 2008). CBCT can also assist in the detection of the so-called accessory mental foramena, identified at a rate of 5-30% of the population which may have escaped the attention of the dentist

before opening the flap (Naitoh et al. 2009). Bone quality is one of the most important factors for the stability of implants and it is difficult to be evaluated with conventional radiographs. Song et al. (2009) showed in their study on 61 patients that CBCT imaging is reliable in such cases and even more useful than CT due to the lower radiation dose and cost.

Endodontics

CBCT can contribute on locating the exact position of root canals and studying their morphology, diagnosing resorption or fracture of the root (especially vertical root fractures are very difficult to diagnose with conventional periapical radiographs), evaluating periapical lesions before endodontic treatment (Patel et al. 2007, Patel and Dawood 2007, Lofthag-Hansen et al. 2007, Stavropoulos and Wenzel 2007, Tyndall and Rathore 2008, Shemesh et al. 2008). After the endodontic treatment, CBCT can be used to evaluate and assess the healing procedure of periapical tissues (Pinsky et al. 2006).

Compared to conventional two-dimensional x-rays, CBCT has been proven to contribute on localizing more root canals in multiple rooted teeth, leading to higher success rates of the root canal treatment (Matherne et al. 2008).

In a research, Estrela et al. compared the accuracy of CBCT with panoramic radiography and intraoral periapical radiographs in the diagnosis of periapical lesions in a sample of 1508 patients with endodontic problems, and found that periodontal problems diagnosed at a higher rate with CBCT (Estrella et al. 2008). In surgical treatment of endodontic problems in anterior teeth, complications are usual, due to their proximity to anatomical structures. Mandibular teeth can be located near the inferior alveolar canal, and maxillary molars near the sinus (Nakata et al. 2006).

Orthodontics

In orthodontics, CBCT imaging can replace all diagnostic imaging currently used such as a lateral and frontal cephalometric radiography, panoramic radiography and any other technique (Huang et al. 2005). Modern technological developments allow for the creation of virtual dental cast for diagnostic reasons (Mah and Redmond 2007).

Many articles in the literature have evaluated the use of CBCT in orthodontics and have proposed analysis methods that can be made in these images respectively to those currently made in lateral cephalometric radiographs. Three-dimensional imaging allows the accurate and reliable estimation of the position of impacted canines and supernumerary teeth, and possible absorption of teeth after orthodontic treatment (Huang et al. 2005).

A series of CBCT imaging can be used to assess the volumetric change of craniofacial structures (Mah and Redmond 2007).

Many articles in the literature have evaluated the use of CBCT in orthodontics and have proposed measurement systems in these images, as currently used for lateral cephalometric. Three-dimensional imaging allows accurate and reliable estimate of the location of impacted canines and supernumerary teeth, and possible absorption of teeth that have undergone orthodontic treatment (Walker et al. 2005).

A series of illustrations CBCT can be used to estimate the volumetric changes of craniofacial structures. Modern software provides the ability to analyze movement, such as movements of the temporomandibular joint and occlusal movements (Enciso et al. 2003a). Furthermore, algorithms have been designed to allow the superposition of three-dimensional images (voxel-based superimposition), with much more reliable results than the two-dimensional digital subtraction radiography used nowadays.

Orthognathics

In orthognathic surgery planning, when patients with significant facial deformities are examined, CBCT can be used as an alternative to CT, when necessary.(Enciso et al. 2003b, Cevidanes et al. 2005, Boeddinghaus and Whyte 2008, Hoffman and Islam 2008, Metzger et al. 2008, Quereshy et al. 2008, Swennen et al. 2009).

Periodontics

CBCT can be used to assess the morphology of the bone with great precision, even comparable to measurements with a periodontal probe (Takane 2010).

CBCT can visualize lesions labial and lingual / palatal, which cannot be seen in conventional two-dimensional radiographs. Thanks to its accurate imaging intraosseous periodontal lesions and cysts can be identified and assessed, without surgical opening of the area.

The contribution of CBCT in evaluating the results of periodontal treatment on bone remodeling is evidence based accepted (Alsherhi et al. 2012). In conjunction with computer software available on the market, a major problem of periodontics, which is the exact placement of resorbable membranes in the

desired area, can be solved. When these membranes are cut and fitted by hand, application is not always as accurate as needed, resulting in a failure to generate bone tissue. However, when designed with the assistance of CBCT imaging, membranes fit more accurately and also the time required intraoperatively is reduced significantly (Takane 2010).

Other uses

CBCT imaging can be particularly useful in cases of orofacial pain or for the diagnosis of osteoarthrosis, osteoarthritis, hypoplasia/hyperplasia/aplasia/relaxation and neoplasmatic tumor of the TMJ (Hilgers et al. 2005, Honda et al. 2006, Honey et al. 2007, Hussain et al. 2008, Alexiou et al. 2009). It has also been used to assess the degree of lesion of the temporomandibular joint from osteomyelitis, and to diagnose other pathological processes in the mouth, such as apical cysts, fibrous dysplasia, cleft and assessment of the sinuses and airway obstruction (Aboudara et al. 2003, Tsiklakis et al. 2004, Honey et al. 2007).

In these cases, the clinician should assess whether the information from the CBCT imaging contribute on the designing of a proper treatment plan and they are not just documentation.

The use of CBCT has been reported in the literature to estimate the age of people, with applications in the field of criminology. For this purpose, the relationship between the pulp and tooth size are estimated (Alshehri et al. 2012).

General Dentistry

CBCT is not suggested to be used in everyday clinical dental practice to detect caries because the dose is significantly higher than conventional radiographs and no additional information is offered (Alshehri et al. 2012).

DISADVANTAGES AND LIMITATIONS OF CONE BEAM COMPUTED TOMOGRAPHY

Despite the obvious advantages resulting from the three-dimensional display technology thanks to CBCT, there are some restrictions on its use and some disadvantages: The resolution offered by modern CBCT scanners (as mentioned above is 0,078-0,4 mm or 1.25-6.5 levels respectively scan per mm) is less than conventional dental radiography (for digital machines resolution is about 8-20 mm per scan plane· Farman and Farman 2005). In contrast to the simple X-ray machines that every dentist has in his dental office, CBCT scanners are not so easily accessible. Usually, the patient is referred to a radiology center or to another dentist with the proper equipment, and the expertise required. Such machines are not yet accessible in the province and therefore the reference of the patient to another city is financially aggravating and time consuming and not always accepted by the patient himself.

Images from CBCT, like all other diagnostic radiographic/imaging techniques are prone to errors display (called "artifacts") that affect reliability. Especially for CBCT these errors can be attributed to four different factors:

–In patient factor.
–In the scanner system.
–In the CBCT machine type used (based on the FOV, the Voxel and the width of the sections).
–In the beam of radiation-X.

Due to the inherent polychromatic nature of the projection of these rays, known in the literature as "beam hardening" (this is a phenomenon caused by the increase in energy due to the absorption of lower energy photons instead of higher energy ones). This phenomenon leads to two types of imaging errors. The first type concerns the distortion of metal structures, known as cupping artifact, while the second one is to show black bands or stripes in the display of objects with different densities. Dental restorations (fillings or apex reverse fillings) within the scanned field, usually lead to errors in strip form. Finally, it should be noted that the high cost of CBCT imaging and the radiation exposure are factors that must be taken into account in relation to the expected benefits (Alsherhi et al. 2012).

The growing popularity of CBCT resulted in many CBCT scanners manufacture companies to promote conference presentations and articles that highlight the advantages. This led to an excessive enthusiasm in scientific fields during the first years of use, leaving disadvantages in a second place. As a result, the European Academy DentoMaxilloFacial Radiology has developed the following principles for the use of CBCT in dentistry (Alsherhi et al. 2012):

1. CBCT examinations must not be carried out unless a history and clinical examination have been performed.
2. CBCT examinations must be justified for each patient to demonstrate that the benefits outweigh the risks.
3. CBCT examinations should potentially add new information to aid the patient's management.

4. CBCT should not be repeated on a patient 'routinely' without a new risk/benefit assessment having been performed.
5. When accepting referrals from other dentists for CBCT examinations, the referring dentist must supply sufficient clinical information (results of a history and examination) to allow the CBCT practitioner to perform the justification process.
6. CBCT should only be used when the question for which imaging is required cannot be answered adequately by lower dose conventional radiography.
7. CBCT images must undergo a thorough clinical evaluation of the entire image dataset.
8. Where it is likely that evaluation of soft tissues will be required as part of the patient's radiological assessment, the appropriate imaging should be conventional medical CT or MR, rather than CBCT.
9. CBCT equipment should offer a choice of volume sizes, and examinations must use the smallest that is compatible with the clinical situation, if this provides a lower radiation dose to the patient.
10. Where CBCT equipment offers a choice of resolution, the resolution compatible with an adequate diagnosis and the lowest achievable dose should be used.
11. A quality assurance program must be established and implemented for each CBCT facility, including equipment, techniques and quality-control procedures.
12. Aids to accurate positioning (light-beam markers) must always be used.
13. All new installations of CBCT equipment should undergo a critical examination and detailed acceptance tests before use to ensure that radiation protection for staff, members of the public and patient are optimal.
14. CBCT equipment should undergo regular routine tests to ensure that radiation protection, for both practice/facility users and patients, has not significantly deteriorated.
15. For staff protection from CBCT equipment, the guidelines of the European Commission document should be followed.
16. All those involved with CBCT must have received adequate theoretical and practical training for the purpose of radiological practices and relevant competence in radiation protection.
17. Continuing education and training after qualification are required, particularly when new CBCT equipment or techniques are adopted.
18. Dentists responsible for CBCT facilities, who have not previously received 'adequate theoretical and practical training', should undergo a period of additional theoretical and practical training that has been validated by an academic institution (university or equivalent).
19. For dento-alveolar CBCT images of the teeth, their supporting structures, the mandible and the maxilla up to the floor of the nose (for example, 8 cm × 8 cm or smaller fields of view), clinical evaluation should be done by a specially trained radiologist or, where this is impracticable, an adequately trained general dental practitioner.
20. For non-dento-alveolar small fields of view and all craniofacial CBCT images clinical evaluation (radiological report) should be done by a specially trained DMF radiologist.

CONCLUSIONS

The more accurate and complete a radiographic image is, the more it contributes in taking the right decisions about treatment planning and execution (Cotton et al. 2007).

The intraoral periapical x-ray is easily and directly accessible, low-cost and provides a satisfactory picture quality, but in some cases the three-dimensional imaging with CBCT, is useful if not necessary.

Possible future use of CBCT technology in dentistry includes virtual 3D learning applications. Software that allows virtual surgery has already been introduced for endodontic reasons, offering the possibility for virtual reconstruction of the bone 1:1, with a very realistic sense of operating on periapical tissues (Heiland 2004c).

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