Journal of Dentistry xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Journal of Dentistry

journal homepage: www.elsevier.com/locate/jdent

The facial effects of tooth wear rehabilitation as measured by 3D stereophotogrammetry☆

Bernadette A.M.M. Sterenborg[a,*], Thomas J.J. Maal[b], Rinaldo Vreeken[b], Bas A.C. Loomans[a], Marie-Charlotte D.N.J.M. Huysmans[a]

[a] Radboud University Medical Center, Radboud Institute for Health Sciences, Department of Dentistry, Nijmegen, The Netherlands
[b] Radboud University Medical Center, Department of Oral and Maxillofacial Surgery, 3D Facial Imaging Research Group, Nijmegen, The Netherlands

ARTICLE INFO

Keywords:
Tooth wear
Restorative treatment
3D stereophotogrammetry
Facial effects

ABSTRACT

Objective: Evaluate the effect of a full rehabilitation, including an increase of vertical dimension of occlusion (VDO), in patients with severe tooth wear on changes in facial appearance.
Methods: Patients with severe tooth wear were restoratively treated using direct composite restorations, including an increase of the VDO. Before and one month after treatment 3D stereophotographs were taken and facial changes were measured with the use of 3D cephalometric landmarks. Cast models were used to determine the Tooth Wear Index (TWI) and the VDO-increase. The Orofacial Esthetic Scale-questionnaire was used to evaluate subjective happiness with appearance. Paired Student's *t*-tests were used to evaluate the changes after full rehabilitation. The relation between the facial changes, VDO-increment and TWI-score were analyzed using multiple regression models ($p < 0.05$).
Results: 44 Patients (35 men, 9 women, mean age: 38.2 ± 7.1 y) participated in this study. Mean TWI-score at baseline was 3.3 ± 0.5 and the mean increase in VDO was 1.6 ± 0.9 mm. Lower face height increased by 1.9 mm ($p \leq 0.001$). Patients reported a significant improvement in orofacial appearance: OES-summary score of 34.3 ± 11.2 before and 59.9 ± 6.8 one month after treatment ($p < 0.001$). The increase of VDO resulted in an increase in Lower Face Height ($p \leq 0.002$), whereas the TWI-score at baseline had no effect on the facial changes. The applied increase in VDO and TWI-score were not related to changes in OES-scores.
Conclusions: A full rehabilitation with an increase in VDO resulted in objective differences in facial height as measured with 3D stereophotogrammetry.
Clinical significance: In patients with severe tooth wear, receiving a full rehabilitation including an increase in vertical dimension of occlusion, an objectively change will occur in the Lower facial height, but this effect will be subjectively judged as a positive change.

1. Introduction

Tooth wear is a clinical problem that is becoming increasingly important in aging populations [1,2]. The most important etiological processes in tooth wear are attrition, erosion and abrasion. Attrition is defined as the mechanical wear resulting from tooth–tooth contact like bruxism. Erosion is defined as pure chemical wear in absence of bacteria, whereas abrasion is the loss of tooth substance by physical means other than opposing teeth [2,3]. In patients with severe tooth wear the etiology is normally multifactorial [4,5].

In general, anterior tooth wear is greater than that in the posterior region, resulting in not only physiologic, but also esthetic alterations [6]. There are two basic biological reactions to occlusal tooth surface loss. There may either be passive tooth eruption with bone remodeling and growth [7], or a lack of bone remodeling may lead to a loss in the vertical dimension of occlusion (VDO) [8]. Changes in lower face height after loss of VDO may manifest themselves as altered facial contour, narrowed vermillion borders and an overclosed commissure [9]. Sagittal assessment of the face may reveal mandibular pseudo-prognathism, a sign of VDO loss and overclosure of the mandible. This observation has been confirmed clinically [10] and anthropologically [11].

The face has been found to be the central feature taken into account in making overall esthetic judgments of others [12], and the esthetics of the face are affected by facial form and facial height. Individual faces may be evaluated in three dimensions of space: transverse, antero-

☆ This research did not receive any specific grant form funding agencies in the public, commercial, or not-for-profit sectors.
* Corresponding author at: Department of Preventive and Restorative Dentistry, Radboud University Medical Center, P.O. Box 9101, NL 6500 HB Nijmegen, The Netherlands.
E-mail address: Bernadette.Sterenborg@radboudumc.nl (B.A.M.M. Sterenborg).

https://doi.org/10.1016/j.jdent.2018.04.014
Received 8 March 2018; Received in revised form 17 April 2018; Accepted 18 April 2018

posterior (A-P), and vertical, the latter two proved to be more important in studies of facial esthetics [13]. Vertical facial form and proportional relationships have been studied and analyzed for centuries [14]. Research shows that, in general, observers prefer the facial proportion of Lower Anterior Facial Height to Total Anterior Facial Height (LAFH/TAFH) to be around 55% [15]. Ratings of facial esthetics decreased as proportions diverted from the norm [16]. Additionally, relationships have been made between changes in VDO and soft tissue LAFH proportions [15].

The traditional method for measuring facial changes is the clinical use of anthropologic spreading calipers, using reference points on the facial soft tissues. This is a relatively easy technique, but measurement errors caused by movement of the repositioning of the spreading calipers are possible [17]. A recent addition to the armamentarium is 3D stereophotogrammetry. This 3D technique can be used to capture the soft tissue surface of the face with correct geometry and texture information [18,19].

Besides the objective measurement of the facial esthetics trough facial measurements, the subjective characterization of the orofacial esthetics of the patient can be determined by using the questionnaire Orofacial Esthetic Scale (OES) [20,21]. This questionnaire aims at aspects such as the appearance of the face and teeth.

Patients with tooth wear may be in need of treatment due to esthetic or functional problems such as pain [22]. To ensure appropriate function and esthetics and to provide enough space for restorations there is often a need to increase the VDO. In case of generalized severe wear normally a full dental reconstruction has to be performed [23–25]. Comprehensive treatment may affect lower facial height and facial esthetics. Therefore, the aim of this study was to evaluate the effect of a full rehabilitation, including an increase of VDO, in patients with severe tooth wear on facial dimensions and facial esthetics.

2. Materials and methods

Patients with tooth wear were referred by general dental practitioners to the Department of Dentistry of the Radboud university medical center (Nijmegen, The Netherlands). The inclusion took place in the period September 2011 till June 2014. Ethical approval (for a larger study of which the current study is a part) was sought and granted before the study was undertaken (ABR code: NL31371.091.10). All patients who were asked to participate agreed and signed an informed consent before entering the study.

2.1. Inclusion/exclusion criteria

The following inclusion criteria were used for selection of the patients: 1) ≥18 years; 2) Moderate to severe generalized tooth wear (TWI ≥ 2); 3) full dental arches, with a maximum of one missing tooth in the posterior area; 4) absence of serious general health problems (ASA-score ≤ 3).

The following exclusion criteria were used: 1) mouth opening < 3.5 cm; 2) temporomandibular pain or dysfunction; 3) periodontitis (pockets > 4 mm); 5) active dental caries or endodontic problems.

2.2. Procedure and registrations

At the intake appointment patients were asked to complete the Orofacial Esthetic Scale-NL (OES) questionnaire. Dental gypsum casts were made and to assess the amount of tooth wear, the Tooth Wear Index (TWI-index) of Smith & Knight was used [26]. Scores ranged between 0 (no loss of enamel surface characteristics) and 4 (complete enamel loss, pulp exposure or secondary dentin exposure). The highest score per tooth was used to calculate a mean TWI-score, which is the combined score of all present teeth per patient. Based on the collected information an individual treatment plan was made for a full rehabilitation with composite resin restorations [23,24]. For each patient the required increase in vertical dimension was estimated taking into account the amount of tooth loss substance and the esthetic wishes of the patient, using an intra-oral mock-up. One month after treatment the questionnaires were filled in again and new impressions and cast models were made. The VDO-increase resulting from the restorative procedure was measured at the location of the first molars (in mm).

Table 1
Results of the intra-observer 3D-cephalometric measurement performance analysis.

Distance	Reliability	DME	Structural difference		
			Diff.	95% CI diff	p-value
Gl-Sn (Midface height)	0.982	0.14	0.10	[−0.34…0.56]	0.619
Sn-Gn (Lower face height)	0.889	0.39	0.59	[−0.61…1.79]	0.308
Sn-St (Nose-interlabial)	0.937	0.15	0.08	[−0.39…0.56]	0.707
St-Gn (Interlabial-chin)	0.859	0.31	1.67	[−0.47…1.45]	0.290

2.3. 3D stereophotogrammetry

Facial 3D stereophotographs were captured using a 3D stereophotogrammetric camera setup and software program Modular System (3dMDfaceSystem; 3dMD LLC, Atlanta, USA), operated by a trained photographer employed at the 3D Facial Imaging Research Group from the department of Maxillofacial Surgery. During the whole procedure, volunteers were seated with a natural head position. Before the image was taken the patient was instructed to swallow, close in maximum intercuspidation, relax and close their lips, and keep their eyes open during image capture [19]. Before treatment and one month after treatment 3 stereophotographs were taken per moment. The best image out of three was used for the analysis. The time range between the stereophotograph before treatment en after treatment was 1.6–7.1 months with mean time difference of 4.1 months.

2.4. 3D cephalometric measurements

Using 3D cephalometric landmarks, facial dimensions on the 3D stereophotographs were measured. Three of these landmarks, Glabella, Subnasale and soft tissue Gnathion were taken from the soft tissue analysis of Plooij [18]. Soft tissue Gnathion (Gn) is the most inferior midpoint on the soft tissue contour of the chin located at the level of the 3D cephalometric hard tissue Menton landmark [27]. One other landmark was added to this analysis: Stomion (St), the midpoint between the upper and lower lip. A modified Swennen soft tissue cephalometric analysis was carried out by one trained investigator using the software program Maxilim® (Medicim NV, Mechelen, Belgium). The study of Plooij showed a high reliability coefficient for intra-observer (0.97 (0.90–0.99)) and inter-observer reliability (0.94 (0.69–0.99)) [18].

The following facial dimensions (in mm) were measured and their changes after treatment calculated: Glabella-Subnasale (Mid-face height), Subnasale-Gnathion (Lower-face height), Subnasale-Stomion (Nose- interlabial height), Stomion-Gnathion (Interlabial/chin height). The dimension Subnasale-Gnathion, equivalent to LAFH, was regarded as the most important in this study.

2.5. Color-coded distance maps

The pre-and post 3D stereophotographs were superimposed using the surface based matching tool of the Maxilim® software package. This resulted in a color-based image indicating the unchanged areas (in white), decreased (in orange) and increased (in blue) facial volumes. A higher intensity of discoloration corresponds with a larger change in facial volume. The distance maps were made and used for visualization purposes only.