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Impact of tooth wear on masticatory performance

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ABSTRACT

Objective: Masticatory performance is influenced by a number of variables such as age, gender, bite force, and occlusal units. Tooth wear may also play a role due to changes in occlusal area and in vertical dimension of occlusion. The aim of this study was to evaluate the effect of tooth wear on masticatory performance, using a communition test.

Materials and Methods: Patients with different degrees of tooth wear, referred by their general dental practitioners, and included in the Radboud Tooth Wear Project, were approached for this study and included after informed consent. The amount of post canine wear was scored with the Tooth Wear Index (TWI). The number of occluding posterior units was quantified and the bite force was measured using a transducer. Masticatory performance was measured with a communition test, with the median particle size (X50) after 20 chewing cycles as outcome measure. A multiple regression model was used to assess the relation between TWI, age, gender, bite force, occlusal units and X50.

Results: 52 participants (40 male, 12 female, mean age: 40 ± 8.2y) were included in the study. The post canine TWI-score was between 1.0-3.3. The average number of occlusal units per participant was 11.9 ± 1.4 and the mean bite force 369 ± 172 N. The mean X50 was 4.2 ± 1.1. The results showed no significant relation between post canine TWI-score, age, gender, bite force, and occlusal units upon the X50 ($p > 0.13$).

Conclusion: This study showed that the degree of tooth wear could not be observed to have an effect on masticatory performance.

Clinical significance: On individual level an effect could be present but looking at a larger group of patients, the degree of tooth wear did not have a relation with masticatory performance as measured with a communition test.

1. Introduction

Efficient chewing refers to the breakdown of food with minimum labour and a maximum rate of particle size reduction [1]. According to Lujan-Climent et al. factors that have an influence on this efficiency are, among others, dental state, bite force, body size, age, gender, salivary flow rate, jaw movements, and temporomandibular disorders (TMD) [2]. The number of functional tooth units and bite force are thought to be of large influence on masticatory performance [3,4]. Another factor that has been investigated is the occlusal contact area. A study showed that the masticatory performance was positively correlated with the occlusal area of the post canine teeth ($r = 0.55$, $p < 0.001$) [5]. This was confirmed in a study in which the occlusal area was experimentally changed by varying the width of a food platform mounted on mandibular removable partial dentures [6].

The factor tooth wear might also be of influence on masticatory performance. Tooth wear is often referred to as 'erosion', indicating that it is the main or only responsible factor. A more suitable term would be 'erosive tooth wear' or just 'tooth wear', as the wear process is known to be complex, and besides the chemical factor of erosion also mechanical factors like attrition and abrasion are important contributors to tooth wear. Especially in cases of severe and pathological wear the etiology will be multifactorial in most cases [7,8].

Tooth wear causes alterations of the morphology of teeth due to loss of tooth substance. This may influence the height of vertical dimension of occlusion (VDO) and may affect patients' function, comfort, esthetics and quality of life [9]. It has been observed that the dentoalveolar complex and masticatory system is dynamic of nature, and although loss of VDO is a possible consequence of tooth wear, dentoalveolar compensatory mechanisms may compensate for this loss [10]. Jain et al. postulate that a reduced VDO due to tooth wear has an impact on bite force. They found that subjects with moderate-to-severe wear of

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occlusal surface had a significantly lower maximum bite force than matched subjects without attrition [11].

Looking at all observed and assumed mechanisms listed above, it is clear that tooth wear may influence masticatory performance in different ways. A resulting loss of VDO, together with or through reduced bite force, may lead to an impaired masticatory performance. Whereas the effect may be absent in cases of dentoalveolar compensation, and even positive due to an increased occlusal area of worn teeth. It was the aim of this study to evaluate the overall clinical effect of tooth wear on masticatory performance. To avoid a major confounding influence of reduced numbers of functional units, only (almost) fully dentate patients were selected.

2. Material and methods

2.1. Participants

Participants with different degrees of tooth wear were referred by their general dental practitioners to the Department of Dentistry, Radboud university medical center (Nijmegen, The Netherlands). This study is a sub-study of a larger clinical trial, called the Radboud Tooth Wear Project (ethical approval was obtained, ABR code: NL31371.091.10). Participants who agreed to participate were asked to sign an informed consent document before entering the study.

2.2. Inclusion/ exclusion criteria (Radboud Tooth Wear Project)

The following inclusion criteria were used for selection of the participants: 1) ≥18 years and mentally competent; 2) mild to severe tooth wear (Tooth Wear Index-score ≥1 [12]), 3) full dental arches, with a maximum of one diastema in the posterior area; 4) ASA-score ≤ 3.

The following exclusion criteria were used: 1) active maximum mouth opening < 3.5 cm; 2) signs of craniomandibular disfunction with pain or restricted jaw movement; 3) periodontitis (DPSI-score ≥3).

Between September 2013 and June 2015 all participants in the Radboud Tooth Wear project were approached for this sub-study, and included after informed consent.

2.3. Measuring methods

2.3.1. Tooth wear index

The Tooth Wear Index of Smith & Knight was used [12]. Scores between 0 (no loss of enamel surface characteristics) and 4 (complete enamel loss, pulp exposure or secondary dentin exposure). For this study the mean TWI score of post canine elements (i.e. premolars and molars) per participant was used. 10% of the data was scored twice in order to obtain an intra-observer reliability.

2.3.2. Dental state

The dental state of each participant was quantified by expressing the number of occluding posterior teeth in occlusal units. An occluding molar pair was counted as two occlusal units, whereas a bicuspid was counted as one occlusal unit.

2.3.3. Bite force measurements

A bite force transducer was used to measure maximum voluntary bite force [13]. In order to protect teeth, both sides of the transducer tips were covered with 6,5 mm thick rubber plates and the whole device was covered with a clean plastic protective shield when used in the mouth. The vertical height of the bite fork was 18 mm. This device was calibrated with loads from 0 to 1050 N by means of compression test machine at our department. Maximum bite force was measured for two different regions: between the first molars on the right and between the first molars on the left side [2]. Participants were encouraged to bite as hard as possible on the transducer for a few seconds. The measurements on each side were performed three times in a row. The mean maximum bite force of all six measurements combined was used for statistical analysis.

2.3.4. Masticatory performance

The masticatory performance of all participants was determined by a masticatory efficiency test consisting of comminution of artificial test food. The test food was made of a polysiloxane impression material; Optosil Comfort Putty (Bayer Dental, Leverkusen, Germany) and the participants chewed on a portion of 17 cubes with an edge size of 5.6 mm (3 cm^3) [14]. The number of chewing cycles was fixed and the examiner counted out loud the number of chewing cycles, 20 in total. Chewed particles were collected in a labeled coffee filter, which were made anonymous by allocation of a number. All participants rinsed their mouth with approximately 100 ml water to collect remaining particles. The air-dried samples were disinfected with 96% alcohol on the same filter. For further analysis, the particles were detached from the filter paper with a powder brush and were dried in an oven for 1 h at 80 °C. The sample was then separated using a series of 12 sieves, with mesh sizes 5.6 mm, 5.0 mm, 4.5 mm, 4 mm, 3.15 mm, 2.8 mm, 2 mm, 1.6 mm, 1.4 mm, 1 mm, 0.71 mm, 0.5 mm and a bottom plate stacked on a mechanical shaker and vibrated for 5 min. Once the particles were separated, the content of each sieve was weighed to the nearest 0.001 g. Every participant performed the test three times, with an interval of 5 min between the tests. Based on each test outcome, the median particle size (X50) was calculated. The average X50 of three tests per participant was used for statistical analysis.

The median particle size (X50) is the size of a theoretical sieve through which 50% of the weight can pass [15]. The masticatory efficiency is defined as the median particle size related to a fixed number of chewing cycles [16]. A small median particle size after a fixed number of chewing cycles indicates that the food has been well fragmented, and therefore, the masticatory efficiency is considered high [17].

2.4. Statistical analysis

Reliability for the TWI-scores was calculated using a weighted Cohen's kappa. Paired Student's t-tests were used to calculate reproducibility of X50. Reliability coefficient was calculated as Pearson´s Correlation coefficient between the three rounds, the duplicate measurement error (DME) was calculated as the standard deviation of the differences between round 1, 2 and 3, divided by √3. To analyze a possible non-random difference between repeated measurements, the mean difference (95% CI, p-value) was calculated. The results of the three rounds were pooled for further analysis.

For measuring the relation of the independent variables, TWI post canine, age, gender, bite force and occlusal units upon the dependent variable X50 a multiple regression model was used. In order to make the intercept of the regression analysis interpretable, all numerical variables in the regression model are centered. All statistical analyses were performed with the Statistical Package for Social Sciences (SPSS 22) and at a significance level of 0.05.

3. Results

In total 52 participants (40 men, 12 women, mean age: 40 ± 8.2y) were included in this study. The mean post canine TWI-score was 2.2 ± 0.6, this score was calculated by one of the authors (BS) with a weighted Cohen's kappa score of 0.603. The average number of occlusal units per participant was 11.9 ± 1.4 and the mean bite force 369 ± 172 N, see Table 1.

The masticatory performance, defined as the median particle size (X50) after 20 chewing strokes, for the whole group was 4.2 ± 1.1. Comparing the resulting X50 scores within patients, a small but statistical significant decrease between successive X50 scores was found. Comparing the first and third value, this decrease was on average 0.26.