Original article

Impact of body mass index on oral health during orthodontic treatment: an explorative pilot study

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Summary

Aim: To answer the question: is there a correlation between body mass index (BMI), oral health, and patient cooperation during multibracket (MB) appliance therapy?

Materials and methods: All adolescent MB patients started and finished between 2007 and 2012 were analysed. According to their pre-treatment BMI, patients were divided into one of the following groups: normal weight, overweight, or obese. Using the patients’ records, the cooperation during treatment was classified as good, bad, or poor and the treatment duration was calculated. Using pre- and post-treatment photographs, white spot lesion (WSL) formation and gingivitis before and after MB therapy were assessed.

Results: Of the 175 subjects, 138 had a normal BMI (79 per cent), 22 were overweight (12.5 per cent), and 15 obese (8.5 per cent). Whereas 42.8 per cent of the normal weight patients showed a good cooperation, only 22.7 per cent of the overweight and 20.9 per cent of the obese patients cooperated sufficiently. On average, normal weight patients were treated for 22.2 months, overweight patients for 23.0 months, and obese patients for 27.7 months. Normal weight patients developed less WSL (41.3 per cent) during MB treatment than overweight (50 per cent) or obese (66.7 per cent) patients. Furthermore, patients with a normal weight or overweight had less gingival inflammation (79.5 per cent) after treatment than obese individuals (93.3 per cent).

Conclusion: An increased BMI appears to be a risk factor for less cooperation, a longer treatment duration, and more oral health-related problems during MB treatment, indicating that these patients require special attention during orthodontic therapy.

Introduction

Over the last decades, overweight and obesity has become a problem in the economically developed world. The increasing number of overweight adults is alarming but also children and adolescents are affected to a dramatic extent (1-4). The World Health Organization (WHO) states that the number of obese has almost doubled since 1980 and that in 2011 more than 40 million children under the age of five were overweight (5). Consequently, the WHO regards childhood overweight and obesity as one of the ‘most serious public health challenges of the 21st century’ (6), especially because the affected children are likely to stay overweight into adulthood.

Furthermore, overweight is associated with a number of secondary health problems. For children with an increased body mass index (BMI), a dramatic increase of pathological processes is described, which normally had only affected adults (4, 7). Besides an increase of type II diabetes and cardiovascular diseases, also an alarming number of joint abnormalities and psychological problems are described (4, 5, 8). Therefore, in general medicine, childhood obesity is already a big issue and these children receive special attention. Concerning oral health, some evidence exists that there might be an association between overweight and an increased caries risk in children (9), but this relationship is not unambiguous (10).
During orthodontic therapy with fixed appliances, the development of white spot lesions (WSLs) is a relatively common negative side-effect (11–14). Taking into consideration, that on one hand overweight adolescents have been shown not to cooperate as well during orthodontic therapy as their normal weight peers (15), and that on the other hand an increased BMI and a higher caries risk are associated (9), the question arises whether or not overweight children have an increased risk of developing WSL during fixed appliance therapy.

Therefore, the aim of this retrospective, explorative study was to compare normal, overweight, and obese orthodontic patients undergoing fixed appliance therapy to analyse intergroup differences concerning the incidence of WSL and gingivitis, the level of cooperation and the treatment duration.

Subjects and methods
The study was approved by the ethics committee of the University of Giessen (104/12). All patients that were treated with multibracket (MB) appliances at the Orthodontic Department at the University of Giessen by different operators between March 2007 and May 2012 were screened. A total of 181 patients that fulfilled the inclusion criteria (Table 1) were consecutively included. Their BMI was calculated based on the pre-treatment weight and height data. The patients were classified as normal weight (normal BMI), overweight (BMI > 90th percentile), or obese (BMI > 97th percentile) (16).

The assessment of WSL and gingivitis was performed on intraoral photographs taken before any orthodontic intervention (T0) and on the day of appliance removal (T1). All photographs were taken in a standardized manner by the same photographer. The evaluation was performed using frontal and lateral intraoral views in full occlusion because this enabled us to have a full view and reproducibly analyse the upper four incisors concerning the development of WSL and the upper and lower gingiva to assess for gingival inflammation.

For a more precise evaluation of pre- to post-treatment changes, T0 and T1 pictures were projected side by side on 1.1 × 1.6 m screens. All evaluations were performed by one single calibrated judge (NL), who was blinded for the BMI. Prior to the analysis, this examiner was calibrated step by step until a consensus of greater than 90 per cent was reached. The classification of the WSL was performed according to the modified WSL index (12, 17) (Table 2). The gingival inflammation was classified using a three-point scale: 0 = none, 1 = slight, 2 = severe (Table 2).

The course of treatment was assessed using the patients’ records. According to the number of negative file entries (poor oral hygiene, insufficient wearing of Class II elastics or headgear, appliance loosening or breakages, loss of ligatures, power chains, or uprighting springs), cooperation was defined as ‘good’ (0–1 negative entries), ‘bad’ (2–4 negative entries), or ‘poor’ (greater than 5 negative entries). Additionally, the active treatment duration was calculated and the number of appointments was recorded. Furthermore, to exclude a possible association between the severity of the malocclusion and treatment duration, the pre-treatment Peer Assessment Rating (PAR) index (18) was measured on plaster casts.

Statistical methods
The study was designed in collaboration with the Institute for Medical Informatics, University of Giessen. Due to a lack of comparable data in the literature, the evaluation was performed in an explorative manner. Statistical evaluation was performed with SAS 9.3 (SAS Institute Inc., Cary, North Carolina, USA) using Fisher’s exact test.

Results
Of the 181 patients who fulfilled the requirements, 138 (79.0 per cent) had a normal BMI, 22 (12.5 per cent) were overweight, and 15 (8.5 per cent) were obese.

The gender distribution in the final sample \( (n = 175) \) was balanced (49.7 per cent males, 50.3 per cent females), but a higher percentage of males compared to females were overweight (16.1 versus 9.1 per cent) or obese (10.3 versus 6.8 per cent; Figure 1). The average pre-treatment age of all patients was 12.9 (SD ± 2.1), with males being slightly older (13.4, SD ± 2.1) than females (12.6, SD ± 2.0).

White spot lesions
Before treatment (T0), 5.7 per cent of all patients presented WSL on at least one of the four upper incisors. Pre-treatment WSLs were least frequent in normal weight (2.7 per cent) compared to overweight (4.5 per cent) and obese (6.7 per cent) patients. All pre-treatment WSLs were categorized as slight (Index 1). No statistical significant differences were found, neither concerning the pre-treatment WSL situation between the different weight groups \( (P = 0.5360) \) nor gender differences \( (P = 0.4779) \).

Table 1. Inclusion and exclusion criteria of the subject sample. MB, multibracket.

<table>
<thead>
<tr>
<th>Inclusion criteria</th>
<th>Exclusion criteria</th>
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<tbody>
<tr>
<td>Completed MB treatment in upper and lower jaw</td>
<td>Craniofacial syndromes</td>
</tr>
<tr>
<td>Pre-treatment age &lt; 18 years</td>
<td>Mental or physical disabilities</td>
</tr>
<tr>
<td>Complete pre- and post-treatment records available</td>
<td>Severe general disease which might influence treatment</td>
</tr>
<tr>
<td>Fillings, veneers, or crowns on incisors</td>
<td>Fillings, veneers, or crowns on incisors</td>
</tr>
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Table 2. Modified white spot lesion (WSL) index and gingivitis score.

<table>
<thead>
<tr>
<th>Score</th>
<th>WSL index</th>
<th>Gingivitis</th>
</tr>
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<tbody>
<tr>
<td>0</td>
<td>No WSL</td>
<td>None</td>
</tr>
<tr>
<td>1</td>
<td>Slight WSL</td>
<td>Slight</td>
</tr>
<tr>
<td>2</td>
<td>Severe WSL</td>
<td>Severe</td>
</tr>
<tr>
<td>3</td>
<td>Cavitation</td>
<td>—</td>
</tr>
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Figure 1. Distribution of the three evaluated weight groups for male \( (n = 87) \) and female \( (n = 88) \) subjects.
After MB treatment (T1), the prevalence of all patients presenting WSL on at least one of the four upper incisors was 44.6 per cent. Here, a relationship between the BMI and the WSL prevalence was found: the higher the pre-treatment BMI, the higher the prevalence for WSL. Whereas 41.3 per cent of the normal weight patients had WSL after MB therapy, this increased to 50 per cent of the overweight and 66.7 per cent of the obese subjects. The corresponding incidence of WSL increased from 35.5 per cent in normal weight patients to 45.5 per cent in overweight and 60 per cent in obese subjects (Figure 2). The majority of the patients developed only slight WSL (Index 1) during treatment. However, the percentage of patients with severe WSL or cavitations (Indices 2 and 3) was remarkably higher in the obese (15.0 per cent) compared to the normal (5.2 per cent) and overweight (4.5 per cent) groups, although statistically not at a significant level ($P = 0.3381$). Independent of the BMI, a higher percentage of male (50.6 per cent) than of female (38.6 per cent) patients developed WSL during MB treatment, although this was not statistically significant ($P = 0.2134$; Figure 3).

**Gingivitis**

Already on the pre-treatment photographs, a slight gingivitis was observed in 49.7 per cent of all patients. An association was found between the pre-treatment BMI and gingival health. Less normal weight (32.6 per cent) and overweight (36.4 per cent) patients presented a slight gingivitis before orthodontic therapy compared to 53.3 per cent of the obese patients ($P = 0.0785$; Figure 4). The amount of patients who had a severe gingivitis (Index 2) before treatment was rather small but also increased with increasing BMI (1.1 per cent normal weight, 4.5 per cent overweight, 6.7 per cent obese). Independent of the BMI, a higher percentage of males (41.4 per cent) than of females (28.46 per cent) had a gingivitis prior to orthodontic therapy, although, due to a wide range of values, statistically not significant ($P = 0.0697$).

The gingival health worsened during treatment. After MB treatment, 86.3 per cent of all patients exhibited a gingivitis on at least one upper incisor. The presence of a gingivitis was associated with the BMI (Figure 5). Whereas 79.5 per cent of the normal and overweight patients presented a gingivitis, this was the case in 93.3 per cent of the obese patients. The amount of patients with a severe gingivitis (Index 2) rose slightly with increasing BMI (23.6 per cent normal weight, 25.0 per cent overweight, 26.7 per cent obese). Females exhibited a gingivitis less frequently (81.8 per cent) than males (90.8 per cent), but this difference did not reach statistical significance ($P = 0.0888$).

**Cooperation**

Based on the retrospective evaluation of the files, there appeared to be an association between the BMI and the patient cooperation. Whereas 42.8 per cent of the normal weight patients had a good cooperation, this was true for only 22.7 per cent of the overweight and 20.9 per cent of the obese patients, once more, not at the level of statistical significance ($P = 0.1686$; Figure 6). Independent of the BMI, females displayed a better cooperation (51.1 per cent good) than males (25.3 per cent good).
3.40. 389 36. 23 22.7 23. 125 per cent of the patients were overweight and 8.5 per cent obese. These numbers are in accordance to those of other recent German studies (23, 24). Kurth and Schaffrath (24) report that the percentage of overweight children increases with age and found 17.0 per cent of the 14–17 years old with overweight and 8.5 per cent with obesity. Authors from other countries, however, report much higher values. Data from the USA or Brazil indicate that nearly 30 per cent of the children and adolescents are overweight or obese (3, 25).

Unfortunately, information concerning the post-treatment BMI was not available, as this was a retrospective study, so it might be that some patients lost or gained weight during orthodontic therapy and thus could end up in another weight group. It has to be kept in mind, however, that the practitioner never knows what will happen during treatment and also other pre-treatment risk assessments such as oral hygiene, probing depths, or temporomandibular disorders might develop in unpredictable ways. The pre-treatment BMI is what the orthodontist can assess before planning and beginning treatment as one of the possible risk factors that might indicate that these patients need more attention during therapy.

White spot lesions

It might be discussed that an intraoral examination could deliver more precise results than the evaluation of photographs, i.e. cavitations might only be validated clinically. Several authors (26–30) have shown, however, that intraoral photographs deliver acceptable data compared to a clinical examination. Furthermore, as this was a retrospective study, the evaluation of photographs by one single calibrated examiner appears to be justifiable. As this examiner was blinded for the different weight groups, the risk of bias is low. However, concerning the comparability to other studies as well as the assessment of the absolute amount of WSL, it might have been more precise to have the assessment performed by more than one examiner. The relative differences between the groups, however, should be comparable, even if the examinations were done by only one single person. The fact that 44.6 per cent of the patients had a certain degree of decalcification on at least one of the four upper incisors after MB appliance treatment is alarming but is clinical reality. Lucchese and Gherlone (31) found WSL in 41.0 per cent of their patients after only 6 months of fixed appliance therapy. Other authors (12) report about even higher percentages (73.5 per cent) of patients who developed WSL during MB treatment. In the present sample, normal weight patients developed significantly less WSL during MB treatment (41.3 per cent) than overweight (50.0 per cent) or obese adolescents (66.7 per cent). Also Willerhausen et al. (9) reported an association between an increased BMI and a decreased dental health in 1290 German school children. Whereas normal weight children had an average df-t index of 1.8, this increased to 2.3 for overweight and 2.2 for obese children. On the other hand, Kopycka-Kedzierawski et al. (10) found only a statistically significant correlation between

Figure 6. Patient cooperation during multibracket treatment in relation to the three different weight groups.
BMI and caries prevalence for 6- to 11-year-old children [National Health and Nutrition Examination Survey (NHANES) 1988–94] when analysing the data of the NHANES of the years 1988–94 as well as 1999–2002. All other age groups showed no interrelation. Therefore, the authors concluded that the reason for the increased BMI was most likely a lack of physical activity and not an increased food intake. Consequently, the higher caries rate was probably not related to an increased food intake but rather to a lower socio-economic background.

Several studies have described that an increased BMI correlates with a weak socio-economic background (32–35). Additionally, in cohorts with a lower socio-economic status, a higher percentage of children is found, which have more dental health-related problems. A survey among first grade children in Berlin, Germany (36), found a healthy dental status in 95.7 per cent of the upper social class, whereas children with a lower social background showed a healthy dentition in only 70.6 per cent. Furthermore, it has been reported that children with a lower social status brush their teeth less frequently (37). Whereas 39.0 per cent of the children with a lower social status reported to brush their teeth only once a day, the corresponding amount was 21.5 per cent in the upper class. Considering the apparent relation between the socio-economic background and oral health (lower social status indicating more oral health-related problems) and the relation between socio-economic background and BMI (lower social status indicating increased BMI), it cannot be excluded that in the present study not the increased BMI per se but rather the lower social status of the high BMI children influenced the dental health in the overweight and obese groups. For this, explorative sample data on the socio-economic status of the families were unfortunately not available but should be surveyed for future, prospectively planned studies.

Gingivitis

Once more, it has to be mentioned that one limiting factor in this retrospective study was that all evaluations were performed on intraoral photographs and were not validated clinically. Consequently, the periodontal situation (attachment loss, tissue breakdown, etc.) could not be analysed. Although it is known that all gingival indices, invasive or non-invasive, are to some degree subjective in nature (38–40), the reliability and validity of a photographic evaluation using the three categories (none, slight, severe) of gingival inflammation may well be considered sufficient for the purpose of this explorative study, especially since all evaluations were performed by one single calibrated observer. Already before any orthodontic intervention, a gingivitis was present in 53.3 per cent of the obese patients (compared to 32.6 per cent of the normal weight subjects). After MB treatment, 79.4 per cent of the normal weight patients had a gingivitis, compared to 79.5 per cent of the overweight and 93.3 per cent of the obese patients. Of course the most obvious reason for gingivitis is the same as for WSL development: poor oral hygiene. On the other hand, it must be kept in mind that obesity is associated with higher levels of pro-inflammatory cytokines (TNF-α, IL-1, IL-6), which play a fundamental role in the progression of periodontitis (41, 42).

Compliance

Already in a pilot study concerning the relation between BMI and orthodontic treatment outcome, it has been shown that overweight patients did not cooperate as well as their normal weight peers and had a longer treatment duration (15). The same was observed for the present subject material, although it has to be remarked that 46 patients of the above pilot study were also included in the present subject material. As all measurements were made retrospectively according to the file entries, it has to be discussed if these entries are reliable. Certainly entries such as ‘did not wear elastics’ or ‘poor oral hygiene’ underlie a certain amount of subjectiveness, others however (i.e. appliance breakages, loss of uprighting springs, or elastics) are very objective and reproducible, as it is quite certain that these appear since they are invoiced. Nevertheless, for a prospectively planned study, it would be advisable to have a checklist for each appointment to minimize bias. Thus, the present findings concerning the cooperation should be considered as a possible trend and have to be confirmed in further studies.

While on the one hand, the poor cooperation might explain the longer treatment duration, on the other hand it might well be that changes in the bone metabolism due to an increased amount of adipose tissue could have influenced the orthodontic tooth movement. It has also been reported that obese patients have a higher bone density (43–48), which is interpreted as the reaction of the bone to the increased load it has to carry. Furthermore, it is known that adipose tissue secretes adipocyte hormones, especially leptin and adiponectin. Leptin has been shown to inhibit both bone formation (46, 47) and resorption through a reduced expression of RANK and RANK ligand and an increased expression of osteoprotegerin (41, 45). Therefore, it seems likely that overweight, which leads to an increase of leptin levels, might imply slower tooth movement due to both the slower bone turnover rate and the higher bone mineral density. Additionally, adiponectin, which decreases in obese patients, has been shown to stimulate osteoblast growth and inhibit osteoclastogenesis (49–51). Once more, for the orthodontist, this could result in slower tooth movement.

Maybe, however, things are a lot simpler, and it is not a matter of skeletal metabolism but merely a question of compliance why the treatment of obese children took longer. As mentioned, a correlation exists between the socio-economic status and overweight, suggesting that the percentage of overweight children to be significantly higher among socially lower status families when compared to those with a higher status (32–35). The insufficient support from home could be the cause for the lack of compliance during orthodontic treatment. Also in other areas of medicine, a poorer compliance of patients with a lower social status has been described in relation to medication non-adherence (52–54).

Eventually, obvious intergroup differences between the general dental health (WSL and gingivitis) of normal, overweight, and obese orthodontic patients were evident, but the reasons for these reasons need to be clarified. Thus, the results of this retrospective, explorative study have to be interpreted with care and must be regarded as the basis for further, prospective research.

Conclusion

An increased BMI appears to be associated with more oral health-related problems (higher WSL and gingivitis incidence) during orthodontic therapy and a longer treatment duration.

References


