ON THE TRACK OF BRUXISM: QUANTITATIVE, QUALITATIVE AND INTRAINDIVIDUAL ANALYSES OF THE BRUXCHECKER® IN DAILY CLINICAL ROUTINE

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ABSTRACT

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Introduction Bruxism is a relevant topic in daily dental routine. Bruxism has to be confirmed by instrumental procedures. The BruxChecker® (BC) is an inexpensive instrument that does not affect the stomatognathic system while used and is suitable for routine use in diagnostics and follow-ups. A novel digital approach for analyzing BC is described, based on first standard values.

Material and Method Within this pilot study, 30 participants (15 males, 15 females) used an upper BC for one night and a lower BC during another night. A standardized digitalization process and a unique software application measured all Tooth Contact Areas (TCAs) on the BC: number and size of each TCAs for each occlusal segment.

Results The mean number of TCAs on upper BC is 28.17 (sd +/-7.84), for lower BC 27.70 (sd +/-7.41). The mean size (mm²) of TCAs on upper BC is 71.81 (sd +/-51.27), for lower BC 68.11 (sd +/-42.64). There are only minor, not significant, gender differences regarding the number and size of TCAs. The transversal right-left TCAs distribution is almost symmetrical; a slightly increased difference can be observed for the size of TCAs right and left. The sagittal distribution of the TCAs shows the dominance of the posterior contacts, while the intermediate segments are least involved.

Conclusion Within the limits of this pilot study and based on the digital analyses of TCAs on BC, the paper presents first standard values and a two-step systematic individual BC analysis.

KEYWORDS

Bruxism; Occlusal Functions; Oral Rehabilitation; Parafunction; Tooth Contact Areas.

1. INTRODUCTION

BC visualizes the contacts between teeth that occur during unconscious teeth grinding or clenching during awake and sleep bruxism. The BC is fabricated for the individual patient using the pressure molding technique. Comparing the actual bruxing scheme on the BC with a so-called optimal centric and eccentric occlusal situation is one suggested possibility to analyze the BC. However, understanding the optimal occlusion does not make it easier to work with the suggested classification scheme. In any case, the BC analyses must consider the laterotrusive and the mediotrusive side contacts during bruxing [1]. A paradigm shift in the assessment of sleep bruxism (SB) took place in recent years. SB is no longer understood solely as a harmful movement disorder.

But the majority of clinicians focus primarily on the possible negative consequences of bruxism: chipping, occlusal trauma, tooth migration, temporomandibular disorder [2]. The issue of the significance of teeth grinding in humans is controversially discussed in medicine. Is it an abnormal function, a movement disorder [3]? Or, in contrast, can SB be assessed as a relevant physiological occlusal function [4]? If one takes this view, then parafunction represents a secondary function beside primary occlusal functions. The increasing acceptance of considering SB as a physiologic function modifies the fundamental methodical approach. Today SB is graduated in possible (based on patient's self-reports), probable (determined by clinical inspection), and definite (verified by an instrumental analysis) [5].

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Dentists are interested in the best possible care for their (bruxing) patients. All diagnostics have impacts on the therapeutic decisions. Expert opinions regarding the best therapeutic concepts of SB differ substantially. Instead of the term "therapy" the phrase "management" is often utilized [6]; however, both terms exclusively refer to the negative consequences of teeth grinding. Based on today's knowledge, there is no indication to treat a most probably physiological oral function. Management recommendations include, among others, behavioral advice, medication, physiotherapy, or physical intervention [7]. The therapeutic goal of "stop bruxing" can never be achieved [8]. Such therapeutic concepts must be regarded as meaningless [9]. Dentists find themselves constricted between these points of view: is a management strategy necessary? Or are occlusal measures to influence/stop bruxism? Are occlusal therapeutic changes indicated or contraindicated in bruxing patients? It must be understood that awake and sleep bruxism will still be executed after occlusal therapy, but maybe with less muscular strength and minor eccentric mandibular movements. The ability and the necessity to influence bruxism by occlusal parameters is still a matter of controversy. Occlusal factors such as the inclination of occlusal guiding structures in the anterior and posterior occlusal segments seem to play an important role in muscle recruitment during bruxism [10]. In silico simulation demonstrated that both the direction and the size of the bruxing force vectors adapt and change due to the position and the inclination of occlusal guiding structures [10]. Grinding areas and occlusal parameters such as anterior occlusal plane and overbite are closely related [11]. The need of an oral Rehabilitation of bruxing patients is a common situation in daily dentistry. Patients present with impaired chewing surface morphology, the risk of increased mechanical and technical complications in prosthodontic Rehabilitation rises. Prosthetic intervention in a patient with (heavy) bruxism without taking into consideration heavy occlusal loading on materials and constructions will end in a breakdown. "Failure to do so may indicate earlier failure than is the norm." [12]. Successful oral Rehabilitation in patients with severely worn teeth seems to be independent of the materials of choice. Direct or indirect materials may be feasible options to restore severely worn teeth [13].

From a clinician's point of view, more clinical studies are required, with a clear focus on the clinical impact on oral structures of bruxism. The decision-making process for successful interventions in bruxing patients requires more detailed and focused studies [14]. As soon as patients recognize symptoms, they demand clarification. A link to awake or sleep bruxism is often not reported by the patient in this stage. The clarification of bruxism using instruments is required to confirm the subjective report of the patient [4]. The various uses of instrumental analysis are known in dentistry and are routine in many dental

clinics. If, however, the use of instruments in bruxing subjects primarily refers to polysomnography [4], the immediate practical implementation is limited by apparent obstacles. Mobile devices that measure the muscle activity of selected masticatory muscles or record the forces on sensors in occlusal devices are available but elude clinical applicability due to missing cut-off values [15]. Devices measuring tooth contacts in centric and eccentric mandibular positions are available and successfully used in restorative dentistry. But such approaches are suitable only to a minimal extent for verifying awake or sleep bruxism, as the measurement takes place in a completely different setting: awake patients, sitting upright in a dental chair, with an invasive measuring instrument placed intraorally, performing artificial mandibular movements trying to simulate unconscious bruxing. The execution of so-called bruxing movements is very different from those performed in various sleeping postures with changing head positions. The BC is a device for such minimally invasive investigation of unconscious tooth contacts during sleep. A classifying evaluation of the BC enables an initial assessment [16]. But occlusion and occlusal structures are core elements in dentistry, and this can be rated as unique proposition of dental clinics. Occlusal Rehabilitation aims to maintain and re-establish oral function such as chewing and bruxing [17].

The BC visualizes functional TCAs. But the interpretation of the BC remains challenging, and many dentists left the use of BC again after their initial enthusiasm. For this reason, the authors of this article suggest a different, systematic approach for the BC analysis based on numerical data. This pilot study aims to determine quantitative and qualitative data of occlusal contacts areas on BruxCheckers for sleep bruxism.

2. MATERIAL AND METHOD

60 already used BC from 30 subjects served as the data source in this exploratory study. Females and males participated in the study. The exclusion criteria comprise persons younger than 16 years and older than 35 years, participants with two or more missing teeth, removable (partial and total) and/or extensive fixed prosthodontic Rehabilitation. This manuscript did not require ethical approval. Each subject signed an informed consent after being informed about the study in detail. The use of the BC followed the guidelines and recommendations of the manufacturer (Scheu Dental, Iserlohn, Germany). The data analysis uses the BC used by the participants for one night; clinical intervention did not take place. Each participant used two BC for one night, but not simultaneously. Only sleep bruxism TCAs were analyzed in this pilot study. Before evaluation, white silicon reinforced the contrast of the TCAs against the red color of the BC.

A validated procedure was applied to digitize the BC. Reproducibility tests demonstrated the soundness of the digitizing process a priori - a series of 7 recordings of 16 BCs (8 upper and 8 lower BC) were included for that test. A password-protected zip folder guarded the data. Finally, the data set listed the automatically measured key figures number and area of TCAs for each BC. The calculation of the maximal differences and the standard deviations for the differences followed. The formula $[\text{means} \pm (\text{sd} \times 1.96)]$ sets an upper and lower tolerance limit. Bland-Altman Diagrams visualized the results. If all means of record 1 to record 7 for all BC were within the upper and lower tolerance limits, adequate reproducibility can be derived (Fig. 1a,1b). For anonymization, a 7-digit unique identifier tags each BC. A short anonymous questionnaire collected information on gender, age, and subjective symptoms, possibly related to grinding and clenching. Table 1 presents the personal functional status of the study participants. In an automatic evaluation process, using a calibrated software (Orehab Minds GmbH, Germany), the number and size of each TCAs were determined and assigned to a specific segment of the occlusion (right-anterior, left-anterior, right-intermediate, left-intermediate, right-posterior, left-posterior). For the statistical analysis, IBM SPSS Statistics 25 was used. The outcome measures are continuous data; a pretest served to estimate the expected standard deviation. The sample size for this pilot study ($n=30$ participants, $n=60$ BC) was set on 20% of the sample size calculation for a planned clinical trial with relevant subgroups (e.g., dental status, gender, age, comorbidity, occlusal characteristics). One hundred fifty participants would still be sufficient to assign minor standardized differences in occlusal contact areas with a power of 80% for two-sided errors of type 1 (alpha) (two-sample t-test). Intra-individual

comparison (e.g., between lateral or sagittal distribution) could recognize an effect size of 0.2 with the same group size (paired t-test) [18]. After the study, all participants received a detailed report on their BC findings.

3. RESULTS

The mean age of all participants was 27 years (sd ± 4.98 years). The female participants had an average age of 26 years with a sd of 5.3 years, the male study participants had an average age of 28 years (sd ± 4.4 years). All participants had a natural occlusion with only minor restorations. 27 (80%) had full dental arches, not considering wisdom teeth. In comparison, 14 (47%) presented one or more of the following findings: lingual retainer of front teeth [4 (13%) upper and 8 (26%) lower]; missing teeth [3 (10%) participant, one missing tooth 14, one missing tooth 37 and one missing tooth 47].

Table 1 presents the subjective functional status of the study participants (personal self-assessment via VAS). The symptom pain for different locations appears with a minimum of 1 and a maximum of 4 on the VAS. The different localizations of the pain showed no noticeable deviations. However, the intensity of the pain, including its impact on activities of daily life (AoDL), individual stress levels, and the reported quality of sleep, are widely spread. Although this pilot study aimed not to identify associations between TCAs and symptoms, the collected data will serve as a basis for further studies to determine whether TCAs' number, size, or distribution are equally related to patients' symptoms.

All 60 BC (30 upper and 30 lower) from 30 individuals are analyzed. The mean value of the number of TCAs for the upper occlusion is $n = 28.2$ (sd ± 7.8) with a minimum number of 11 and a maximum number of 39 TCAs (Fig. 2a). The mean value of the number of TCAs for the lower occlusion is 27.7 (sd ± 7.4), with

Figure 1a. Bland-Altman-Diagram to demonstrate the reproducibility of the analytic process for BC. Here, the measurement parameter is the number of TCAs on upper BC. 8 BC were included; digitizing was repeated 7 times per BC (56 records in total). The mean difference (1,5) and the tolerance limits (upper: 4,46 and lower: -1,46) were calculated. The mean differences per BC are indicated (•); all are located between the upper and lower limit. No outliers are detectable; the limits are not exceeded. A slight dependence on the number of TCAs may exist.

BC BruxChecker; TCAs Tooth Contact Areas.

Figure 1b. Bland-Altman-Diagram to demonstrate the reproducibility of the analytic process for BC. Here, the measurement parameter is size of TCAs on upper BC. 8 BC were included; digitizing was repeated 7 times per BC (56 records in total). The mean difference (0,6) and the tolerance limits (upper: 1,03 and lower: 0,168) were calculated. The mean differences per BC are indicated (•); all are located between the upper and lower limit. No outliers are detectable; the limits are not exceeded. A slight dependence on the number of TCAs may exist.

BC BruxChecker; TCAs Tooth Contact Areas.

Parameter VAS 0-10	Mean	sd	min	max
tooth_ache*	3.77	0.68	1	4
headache*	3.67	0.55	2	4
backpain*	3.30	0.70	1	4
facialpain*	3.93	0.37	2	4
temporal_pain*	3.90	0.40	2	4
ear_tmj_pain*	3.77	0.57	2	4
pain_mouth_open*	3.83	0.46	2	4
pain_mastication*	3.87	0.43	2	4
AoDL_influenced*	3.10	1.73	1	8
overall_pain_intensity*	3.00	1.64	1	8
sleep_quality*	7.00	1.80	4	10
stress_level* 1	5.80	1.77	2	9

Table 1. Overview: reported symptoms of the participants. These data were not collected to analyze correlations of TCAs (number and/or size) with subjective complaints but to check the sample for consistency and to support future sample size calculations.

TCAs Tooth Contact Areas; sd standard deviation, min minimum; max maximum, AoDL Activities of Daily Living, VAS Visual Analog Scale.

Figure 2a. Histogram to show the distribution of the number of TCAs for all upper BC, females and males. The mean number of TCAs is 28.17 with a sd of 7.844 and a range of 28 (minimum 11, maximum 39). Based on this sample, a normal distribution cannot be assumed (KS Test, $p=0.019$).

BC BruxChecker; TCAs Tooth Contact Areas; KS test Kolmogorov-Smirnov Test.

Figure 2b. Histogram to show the distribution of the number of TCAs for all lower BC, females and males. The mean number of TCAs is 27.7 with a sd of 7.405 and a range of 30 (minimum 13, maximum 43). Based on this sample, a normal distribution can be assumed (KS Test, $p=0.2$).

BC BruxChecker; TCAs Tooth Contact Areas; KS test Kolmogorov-Smirnov Test.

a minimum number of 13 and a maximum number of 43 (Fig. 2b). The mean size of TCAs is 71.8mm² (sd +/- 51.3mm²) for the upper occlusion and 68.1mm² (sd +/- 42.6mm²) for the lower occlusion. The range of TCAs size for upper occlusion encompasses a span from 13mm² to 224mm² or from 11mm² to

Figure 2c. Histogram to show the distribution of the size of TCAs for all upper BC, females and males. The mean number of TCAs is 71.81 with a sd of 51.273 and a range of 211 (minimum 13, maximum 224). Based on this sample, a normal distribution cannot be assumed (KS Test, $p=0.021$). Measurements in mm².

BC BruxChecker; TCAs Tooth Contact Areas; KS test Kolmogorov-Smirnov Test.

Figure 2d. Histogram to show the distribution of the size of TCAs for all lower BC, females and males. The mean number of TCAs is 68.11 with a sd of 42.643 and a range of 183.5 (minimum 11, maximum 194.5). Based on this sample, a normal distribution cannot be assumed (KS Test, $p=0.047$). Measurements in mm².

BC BruxChecker; TCAs Tooth Contact Areas; KS test Kolmogorov-Smirnov Test.

194.5mm² for the inferior occlusion (Fig. 2c, 2d), respectively. Table 2a and 2b summarizes these results. Kolmogorov-Smirnov Tests (KS test) tested the null hypotheses "Within this sample, number and size of TCAs are normal-distributed." For the upper BC, a normal distribution for both number (KS test, $p=0.019$) and size (KS test, $p=0.021$) of TCAs cannot be assumed; for the lower BC, a normal distribution cannot be assumed for size (KS test, $p=0.047$), but for the number of TCAs (KS test, $p=0.2$).

The comparison between females and males shows only minor, not significant differences for number of TCAs: for the males, an average of 29.13 (sd +/- 8.55) TCAs for the upper occlusion; for the females, 27.2 (sd +/- 7.25); for the lower occlusion, an average of 27.13 (sd +/- 6.01) TCAs for males, for the females 28.26 (sd +/- 8.77), respectively. The following data can be described for the size of TCAs: males, upper occlusion: 87.27mm² (sd +/- 57.88mm²), females, upper occlusion: 56.35mm² (sd +/- 39.79mm²); males, lower occlusion: 80.38mm² (sd +/- 46.11mm²), females, lower occlusion: 55.83mm² (sd +/- 36.29mm²) (Tab. 3). The minimal differences between women and men related to TCAs also appear in the direct comparison (Fig. 3a, 3b) [Mann-Whitney U test for size of TCAs: upper BC $p=0.09$; lower BC $p=0.08$; Mann-Whitney U test for number of upper BC: $p=0.37$; independent samples t-test for number of lower BC: $p=0.6$].

Upper BruxChecker®	Number of Tooth Contact Areas (n)	Size of Tooth Contact Areas (mm²)
N	30	30
Mean	28.1667	71.81
sd	7.84366	51.27321
Minimum	11.00	13.00
Maximum	39.00	224.20

Table 2a. Key figures for number and size of TCAs of upper BC, male and female participants.

TCAs Tooth Contact Areas; BC BruxChecker; sd standard deviation.

Lower BruxChecker®	Number of Tooth Contact Areas (n)	Size of Tooth Contact Areas (mm²)
N	30	30
Mean	27.7000	68.1067
sd	7.40526	42.64273
Minimum	13.00	11.00
Maximum	43.00	194.50

Table 2b. Key figures for number and size of TCAs of lower BC, male and female participants.

TCAs Tooth Contact Areas; BC BruxChecker; sd standard deviation.

Figure 3a. Comparison of number of TCAs for females and males, shown for upper and lower BC. Boxes indicate the IQR [Q3-Q1], the lines (-) indicate the median (Q2). The whiskers are limited by minimum and maximum. Outliers (o) are identified if the distance to Q1 or Q3 is bigger than IQR multiplied by 1.5. In such cases, the whiskers are limited by the value that just does not represent an outlier.

TCAs Tooth Contact Areas; IQR Interquartile Range; Q1 First Quartile, Q2 Second Quartile, Q3 Third Quartile.

Figure 3b. Comparison of size of TCAs for females and males, shown for upper and lower BC. Boxes indicate the IQR [Q3-Q1], the lines (-) indicate the median (Q2). The whiskers are limited by minimum and maximum. Outliers (o) are identified as such if the distance to Q1 or Q3 is bigger than IQR multiplied by 1.5. In such cases, the whiskers are limited by the value that just does not represent an outlier.

TCAs Tooth Contact Areas; IQR Interquartile Range; Q1 First Quartile, Q2 Second Quartile, Q3 Third Quartile.

Females		Number of Tooth Contact Areas	Size of Tooth Contact Areas
Upper BruxChecker® 15 BC analysed	Mean	27.2000	56.3533
	sd	7.24273	39.79228
Lower BruxChecker® 15 BC analysed	Mean	28.2667	55.8333
	sd	8.76247	36.29183

Table 3a. Key figures for number and size of TCAs of upper and lower BC, female participants.

TCAs Tooth Contact Areas; BC BruxChecker; sd standard deviation.

Males		Number of Tooth Contact Areas	Size of Tooth Contact Areas
Upper BruxChecker® 15 BC analysed	Mean	29.1333	87.2667
	sd	8.54289	57.88172
Lower BruxChecker® 15 BC analysed	Mean	27.1333	80.3800
	sd	6.01031	46.11729

Table 3a. Key figures for number and size of TCAs of upper and lower BC, male participants.

TCAs Tooth Contact Areas; BC BruxChecker; sd standard deviation.

Further attention during the analyses of BC has to be paid to the distribution of TCAs right and left, the transversal (lateral) distribution. The number of TCAs is almost identical on the right and left sides (Fig. 4a). There are minor differences in the distribution of the size of TCAs on the right and left (Fig. 4b). Tab. 4a and 4b present these results. The transversal (lateral) distribution seems to be regardless of the number or the size of TCAs (Fig. 4c, 4d). The evaluation of the sagittal distribution weighs three sections: anterior (corresponds largely to anterior teeth including the canine), intermediate (corresponds largely to the premolar region), and posterior (corresponds largely to the molar region). The sagittal distribution of TCAs in the upper jaw is 8.2 (sd +/- 3.3) anterior, 7.5 (sd +/- 2.5) intermediate, and 12.5 (sd +/- 4.8) posterior. The sagittal distribution of TCAs in the lower jaw is 8.3 (sd +/- 3.1) anterior, 6.6 (sd +/- 2.1) intermediate, and 12.8 (sd +/- 4.6) posterior. The following values describe the mean size of TCAs: for the upper occlusion 28.2mm² (sd +/- 23.7mm²) anterior, 13.9mm² (sd +/- 10.8mm²) intermediate

Figure 4a. Comparison of the transversal (lateral) distribution of number of TCAs for total vs. right vs. left. Total (□), right (◀), and left (▶) TCAs are shown for upper and lower BC (males and females).

TCAs Tooth Contact Areas; BC BruxChecker.

Figure 4b. Comparison of the transversal (lateral) distribution of size of TCAs for total vs. left vs. right. Total (□), right (◀), and left (▶) TCAs are shown for upper and lower BC (males and females).

TCAs Tooth Contact Areas; BC BruxChecker.

Figure 4c. Scatter plot for size of right vs. left TCAs for the upper BC (males and females). The R^2 value of 0,873 shows a tendency towards a symmetrical lateral distribution of the number of TCAs.

TCAs Tooth Contact Areas; BC BruxChecker; R^2 coefficient of determination.

Figure 4d. Scatter plot for size of right vs. left TCAs for the lower BC (males and females). The R^2 Value of 0,704 shows a tendency towards a symmetrical lateral distribution of the size of TCAs.

TCAs Tooth Contact Areas; BC BruxChecker; R^2 coefficient of determination.

and 29.7mm² (sd +/- 24.9 mm²) posterior; for the lower occlusion: 23.7mm² (sd +/- 17.2mm²) anterior, 12.3mm² (sd +/- 8.8mm²) intermediate and posterior 32.2mm² (sd +/- 24.5mm²) posterior. The results are summarized in Tables 5a and 5b and shown in Figures 5a and 5b. A TCAs may exceed the midline (right-left) or the boundaries between sections (anterior-intermediate or intermediate-posterior). In such situations, TCAs are split up and allocated proportionally to both sides of the adjacent sections. The areas are measured per TCAs and summed up for each segment. Rounding errors can lead to minimal inaccuracies in the automatic summation in the decimal places.

Figure 5a. Comparison of the sagittal distribution of the number of TCAs for anterior vs. intermediate vs. posterior. Anterior (▲), intermediate (●), and posterior (◆) number of TCAs are shown for upper and lower BC (males and females). Posterior sections are dominantly involved, while the intermediate sections have the lowest number of TCAs. Similar distributions are shown for upper and lower BC.

TCAs Tooth Contact Areas; BC BruxChecker.

Figure 5b. Comparison of the sagittal distribution of the size of TCAs for anterior vs. intermediate vs. posterior. Anterior (▲), intermediate (●), and posterior (◆) size of TCAs are shown for upper and lower BC (males and females). The dominance of posterior sections can only be seen for lower BC, while the anterior and posterior sections of the upper BC are almost equally involved. The intermediate sections show the smallest sizes of TCAs.

TCAs Tooth Contact Areas; BC BruxChecker.

Based on this pilot study, the authors recommend a two-step procedure for the systematic BC analysis: Step 1 - Quantitative analysis; Step 2 - Qualitative Analysis. In the future, an option of a third step (intra-individual analysis) for individual occlusal planning exists.

Step 1 - Quantitative analysis

The quantitative analysis of a BC: based on the measured critical numbers for number and size; the extent to which the individual uses occlusion when bruxing during sleep, compared to average values (Fig. 6).

Step 2 - Qualitative analysis

Understand the distribution of TCAs on the BC is a crucial element in occlusal functional analysis. The following assumptions facilitate the qualitative analysis of a BC: involvement of all occlusal sections; symmetric transversal distribution; the sagittal distribution shows the dominance of the posterior occlusal segments, both for the number and the size of TCAs, followed by the anterior segments. The intermediate section shows the least participation (Fig. 7).

Typically, the dental focus is on "large" and "eye-catching" grinding spots. However, such a focus inhibits a deeper understanding of the involved

occlusion. It is essential to pay attention to those occlusal sections not used in bruxing. In addition, it might be helpful to superimpose the visible TCAs on the BC and the functional structures of the occlusal morphology (Fig. 8).

Figure 6. The quantitative analysis of an individual BC based on the measured key numbers for number and size of TCAs; value table and graphical overview.

TCAs Tooth Contact Areas; BC BruxChecker.

Figure 7. The qualitative analysis of an individual BC based on the bar charts to point out the transversal and sagittal distribution of TCAs.

TCAs Tooth Contact Areas; BC BruxChecker.

Figure 8. An additional opportunity to use an individual BC is the intra-individual occlusal analysis in comparing the distribution of actual and expected TCAs within the dental arches.

TCAs Tooth Contact Areas; BC BruxChecker.

4. DISCUSSION

From the authors' point of view, the quantitative approach is an advantage to understand the BC, and thus for tooth grinding pattern of the individual patient. The claim for instrumental confirmation by the SB is fulfilled [4]. The key figures support the possibility to compare the individual situation with standard values and expectations for optimized occlusion [3,16,17,19]. The distribution of TCAs for the upper and lower occlusion is symmetric for the transversal (lateral) distribution and well-adjusted in the sagittal distribution. The following concepts may explain the quantitative differences between upper and lower BC: a) different nights: bruxing activity varies from night to night; b) The lower dental arch is smaller than the upper dental arch. c) grinding of teeth has different effects on the upper and lower teeth, especially on anterior teeth: while the lower front teeth will contact with a relatively small area during the entire bruxing movement, the upper front teeth will be "used" widely – from centric occlusion contact points up to the incisal edge. In the premolar and molar regions, these differences are less significant.

This quantitative approach to BC enables the clinician not only to focus on adverse effects [1,6,8, 12,13] but instead on therapeutic aspects – which occlusal parameters to be changed [10,11,17]. It seems possible to change the muscle recruitment during bruxing activity by modifying occlusal structures [10,11], based on an increased alertness of dentists for TCA's and their distribution by BC visualization and numerical analyses. In addition, it appears reasonable to alter bruxing patterns by the design of occlusal parameters such as canine guidance concerning the temporomandibular joint movement pattern [17].

The BC constitutes a clinically suitable instrument for long-time observation and a functional recall after Rehabilitation. It is up to the supervising team whether other diagnostic methods should be used [1,2,4,11].

Missing teeth may influence the quantitative analysis of a BC. The number of the OCA's on the upper BC of participant with missing teeth are close to the sample mean (missing first premolar: 36 TCAs; missing first lower molar: 29 TCAs; missing second lower molar: 30 TCAs). The size of the OCA's on the upper BC of these participant are close to the sample mean (missing first premolar: 96.7mm² TCAs; missing first lower molar: 69.2mm² TCAs; missing second lower molar: 80.82mm² TCAs). The number of the OCA's on the lower BC of these participant are close to the sample mean (missing first premolar: 36 TCAs; missing first lower molar: 22 TCAs; missing second lower molar: 15 TCAs). The size of the OCA's on the upper BC of these participant are still high and close to the sample mean (missing first premolar: 92.4mm² TCAs; missing first lower molar: 63.2mm² TCAs; missing second lower molar: 38.9mm² TCAs). Missing teeth have to be considered in the BC analyses. The effect of absent teeth on the key figures of BC analysis has to be evaluated in future studies

5. CONCLUSION

- The average size of TCAs in this study population shows a high variance (72mm² +/−51 mm²).
- The average number of TCAs in this study population is 28 with a sd of +/−8.
- There is only a not significant gender-specific difference.
- The lateral distribution of TCAs is symmetrical for both number and size.
- The sagittal distribution shows a dominance of the posterior occlusion.
- Based on the quantitative analysis, the clinician has the option to assess occlusion with the number and size of TCAs and thus perform a functional-occlusal analysis: all sections of occlusal seems to be involved in bruxing.
- In the future, dentists' attention can be focused more on the number of TCAs in combination with the size of TCAs: few but large TCAs should be seen differently compared to many but small TCAs.

- Occlusal segments without any TCAs have to be seen as critical as those with huge TCAs
- Based on the knowledge of the distribution of number and size of TCAs, a qualitative analysis of the BC serves as a valuable element in the functional assessment of the individual occlusion.

AUTHOR CONTRIBUTIONS

GS: contributed to the concept, protocol, data gathering and analysis, their interpretation and critically revising the manuscript.
 DG: contributed to the concept, protocol, data gathering and

analysis and critically revising the manuscript. AN: contributed to the gathering and analysis, their interpretation and critically revising the manuscript. FS: contributed to the data analysis, their interpretation and critically revising the manuscript.

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CONFLICT OF INTEREST

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Dr. Slavicek is an MD, specialized in Dentistry. He is currently Director of the Steinbeis Transfer Institute Biomedical Interdisciplinary Dentistry, Steinbeis University Berlin. Since 2019, he has been CEO of Orehab Minds GmbH in Stuttgart, Germany. He graduated from the University Vienna (medicine and dentistry), also specializing in Clinical Research at the same university (Master of Science). He attended additional postgraduate orthodontic training at University Aarhus (Denmark), Prof. B. Melsen, and postgraduate gnathological training at University of Florida (USA), Prof. H. Lundeen and Prof. C. Gibbs. He is an honorary member of the Italian Gnathological Society. He was awarded an honorary professorship by the Ukrainian Dental Society. He was visiting professor at the first medical state University in Moscow Sechenov (2014-2018).

Questions

1. How can bruxism be graduated according to the actual international consensus?

- ☐ a. Possible, confirmed, severe;
- ☐ b. Possible, probable, definite;
- ☐ c. Confirmed and not definite;
- ☐ d. Possible, harmless, sometimes.

2. Which number of tooth contact areas to expect on an upper BruxCheckers® (males and females)?

- ☐ a. Number: 8 +/-2;
- ☐ b. Number: 71 +/-51;
- ☐ c. Number: 28 +/-8;
- ☐ d. Number: 101 +/-51.

3. Which size of tooth contact areas to expect on an upper BruxCheckers® (males and females)?

- ☐ a. Size: 71mm² +/-51mm²
- ☐ b. Size: 7,1mm² +/-5,1mm²
- ☐ c. Size: 17mm² +/-15mm²;
- ☐ d. Size: 171mm² +/-151mm².

4. Which answer is correct?

- ☐ a. The lateral distribution of tooth contact areas on BruxCheckers® is almost symmetrical;
- ☐ b. The posterior segments are dominant in the sagittal distribution of tooth contact areas on BruxCheckers®;
- ☐ c. There are only minor differences between females and males regarding tooth contact areas;
- ☐ d. Answers 1-3 are correct.

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