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Evaluation of the effectiveness of the new tooth wear measurement parameters

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Abstract: Nowadays, there has been an increasing interest in the preservation of natural dentition and the proper occlusion related to tooth wear for quality of life. To overcome the problems of the existing qualitative tooth wear analysis method, virtual three-dimensional models have been used. This study was designed to develop and validate a new quantitative method using tooth wear measurement parameters with angles obtained from virtual vectors and planes of the three-dimensional models. Sixteen parameters were evaluated in the virtual models of 20 students (7.57±1.55 years old) and 20 adults (56.85±6.34 years old). There were 12 angle and 4 height parameters, and the number of parameters measured from the virtual planes and vectors were 10 and 6, respectively. For each parameter, means and standard deviations were calculated, and an unpaired sample t test was performed to compare the young and the adult groups. Also, differences between the means were determined and expressed as percentages. The results were statistically significant between the two groups ($P<0.001$). In general, parameters using virtual vectors showed greater change than virtual plane. Although there were statistically significant differences among all parameters using virtual planes ($P<0.001$), the changes of the three angles were similar, except distolingual cusp angle. It was found that the parameters using virtual vectors were effective and tooth wear took place in both buccal and lingual cusps. Likewise, the validation of the new measurement parameters suggests that they can also be applied in the assessment of tooth wear related to dental biomaterials.

Key words: Tooth wear, Validity, Virtual models, Measurement parameters

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Introduction

The average life expectancy of Koreans is continuing to increase with improvement in income and social environment. Thus, there has been a growing interest in dentistry to retain natural teeth and maintain proper occlusion as teeth wear.

Typically, tooth wear occurs naturally with age through attrition, abrasion, and erosion. [1, 2], and is also influenced by a combination of various factors such as enamel composition, diet, mastication and oral health, number of existing teeth, bruxism, and saliva buffering capacity. Therefore, it is a challenge to find the actual cause of tooth wear that has already developed, especially on the occlusal surface, and the condition of the dentition will be the sole basis for diagnosis. Furthermore, dental biomaterials play an important role in the tooth wear as the restorative materials may cause loss of tooth structures and vice versa [3]. For these reasons, establishing appropriate criteria for the diagnosis of tooth and restorative material wear is fundamental in clinical dentistry.

Tooth wear has been diagnosed qualitatively through clinical observations. Consequently, many tooth wear indices were developed and validated for the purpose of better evaluation, but the measurements were based on a scoring system which relied on the observer's judgment.

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Because of this subjective assessment, there is a need for a specific guideline. Also, measurement depends largely on the observer's competence, so compensation is needed even after an evaluation by a well-trained person. A classic example of tooth wear indices is by Smith and Knight [4], and some researchers used this index according to the direction of their research through appropriate modifications. Therefore, as there are many types of indices available, comparing research findings and exchanging ideas between researchers can be challenging [4-7].

In order to overcome these problems, quantitative analysis was evaluated. Once the measurement parameter is determined on the virtual model, same values can be repeatedly produced with no variability among the observers. The virtual three-dimensional model was developed for use in the engineering field, but in recent years, its applications have been expanded to the research and clinical practices of dentistry and medicine. There are direct method of using intraoral scanner and indirect method of scanning plaster model when producing the virtual model, and each has its own advantages and disadvantages. One of the advantages of using these methods is that the model can be saved to the computer, making storage and access of data simple for its use in other applications. In addition, accuracy of these methods has been confirmed in several studies [8-10]. Three-dimensional measurements and complex calculations, which were impossible with the conventional method, can be made based on virtual vectors or planes. In this laboratory, quantitative analysis of tooth wear [11] and its verification [12] have already been performed through these methods. From the studies, it was revealed that the height of arches and angles between cusp tips measured from the virtual vectors and planes are more useful than the distance measured from cusp tip to central pit. However, there are few significant measurement parameters available due to the broad parameter range, and so far only the comparison analysis of the qualitative data has been made on the amount of tooth wear. Therefore, the purpose of this study was to develop a quantitative method of predicting tooth wear by using angles formed through virtual vectors and planes from a virtual three-dimensional model and confirm which parameter will be utilized most effectively in the evaluation of tooth wear and dental restorative materials.

Materials and Methods

Selection of dental models

Total of 40 dental casts from 20 first- or second-grade elementary school students (7.57±1.55 years old) and 20 adults aged 20 and older (56.85±6.34 years old) were used. In order to validate the effectiveness of the index, maxillary casts with sound first molar were selected regardless of gender, and for elementary school students, dental models with the least amount of tooth wear were chosen. Casts with decayed, restored or severely worn first molars were excluded for eliminating factors affecting first molars occlusal wear status. Casts showing malocclusion were also excluded. This study was approved by the Institutional Review Board of the School of Dentistry, Seoul National University.

Scanning and reconstruction of the virtual three-dimensional models

The research was conducted based on the previous evaluation methods and findings by Lee et al. [12]. Virtual three-dimensional models were made using autoscan system for dental application (INUS Technology Inc., Seoul, Korea). The entire external surfaces, including undercut region, of each cast were scanned 10 to 20 times with a 3-D scanner (optoTOP-HE, Breukmann, Meersburg, Germany), and the data were reconstructed into polygonal models through triangulation process. Then the models were combined and rendered, using RapidForm XO software (INUS Technology Inc.). In order to generate a virtual three-dimensional model, common reference points were marked on each cast, and the models were aligned based on these points and merged into one. Overlapping regions were removed through the merging process for the finalization of the model.

Measurement and analysis of model

RapidForm 2004 software (INUS Technology Inc.) was used to designate reference points on the maxillary right and left first molars, and each point was utilized for the desired tooth wear measurement parameter. The highest point of 4 cusps (mesiobuccal cusp, mesiolingual cusp, distobuccal cusp, distolingual cusp) and the lowest point in the center of the occlusal surface (central pit) were chosen as the reference points through the automatic labeling function of the software. Also, the observer marked total of 7 points from the lowest point of each line connecting two buccal cusps and two lingual cusps. The reference points were defined as follows:

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(1) Mesiobuccal cusp point (MBCP): the highest point of mesiobuccal cusp, (2) mesiolingual cusp point (MLCP): the highest point of mesiolingual cusp, (3) distobuccal cusp point (DBCP): the highest point of distobuccal cusp, (4) distolingual cusp point (DLCP): the highest point of distolingual cusp, (5) central pit point (CPP): the deepest point of central pit, (6) buccal lowest point (BLP): the lowest point on the outline connecting buccal cusps, and (7) lingual lowest point (LLP): the lowest point on the outline connecting lingual cusps.

For tooth wear measurement, 10 types of virtual vectors and 2 types of virtual planes were formed with the reference points as follows (Fig. 1).

(1) Mesiobuccal cusp vector 1 (MBV1): the vector connecting MBCP and CPP, (2) distobuccal cusp vector 1 (DBV1): the vector connecting DBCP and CPP, (3) mesiolingual cusp vector 1 (MLV1): the vector connecting MLCP and CPP, (4) distolingual cusp vector 1 (DLV1): the vector connecting DLCP and CPP, (5) mesiobuccal cusp vector 2 (MBV2): the vector connecting MBCP and BLP, (6) distobuccal cusp vector 2 (DBV2): the vector connecting DBCP and BLP, (7) mesiolingual cusp vector 2 (MLV2): the vector connecting MLCP and LLP, (8) distolingual cusp vector 2 (DLV2): the vector connecting DLCP and LLP, (9) buccal cusps vector (BV): the vector connecting MBCP and DBCP, (10) lingual cusps vector (LV): the vector connecting MLCP and DLCP, (11) buccal occlusal plane (BP): the plane consisting of MBCP, DBCP, and MLCP, and (12) lingual occlusal plane (LP): the plane consisting of MBCP, MLCP, and DLCP.

The reference points, virtual vectors, and virtual planes for the measurement parameters are as follows (Fig. 2):

(1) Mesiobuccal cusp angle with BP (MBCA_BP): the angle between MBV1 and BP, (2) distobuccal cusp angle with BP (DBCA_BP): the angle between DBV1 and BP, (3) mesiolingual cusp angle with BP (MLCA_BP): the angle between MLV1 and BP, (4) distolingual cusp angle with BP (DLCA_BP): the angle between DLV1 and BP, (5) mesiobuccal cusp angle with LP (MBCA_LP): the angle between MBV1 and LP, (6) distobuccal cusp angle with LP (DBCA_LP): the angle between DBV1 and LP, (7) mesiolingual cusp angle with LP (MLCA_LP): the angle between MLV1 and

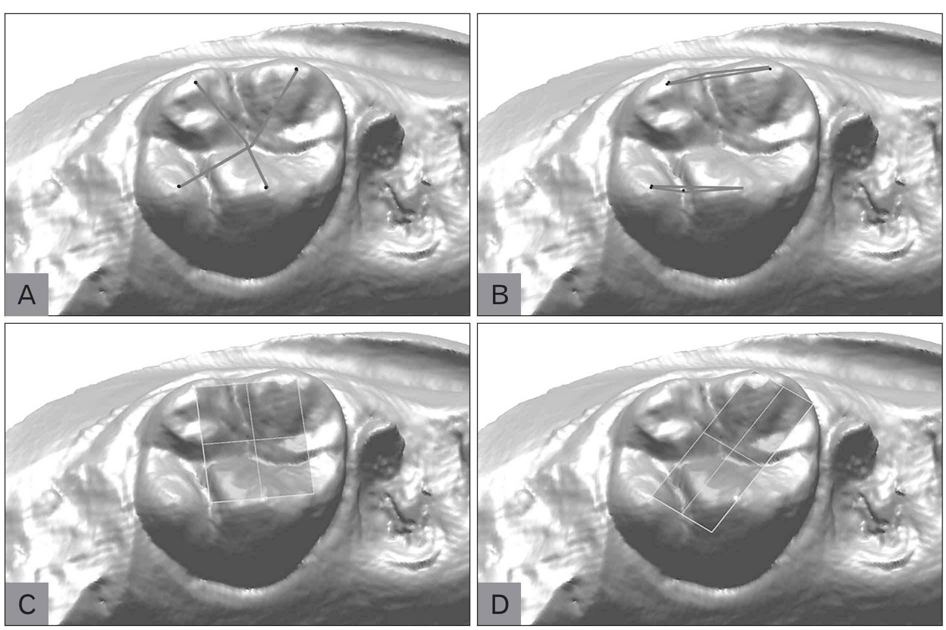

Fig. 1. Reference points, vectors, and planes. (A) MBV1, DBV1, MLV1, DLV1. (B) MBV2, DBV2, MLV2, DLV2, BCV, LCV. (C) BP. (D) LP. MBV1 (mesiobuccal cusp vector 1), the vector connecting mesiobuccal cusp point (MBCP) and central pit point (CPP); DBV1 (distobuccal cusp vector 1), the vector connecting distobuccal cusp point (DBCP) and CPP; MLV1 (mesiolingual cusp vector 1), the vector connecting mesiolingual cusp point (MLCP) and CPP; DLV1 (distolingual cusp vector 1), the vector connecting distolingual cusp point (DLCP) and CPP; MBV2 (mesiobuccal cusp vector 2), the vector connecting MBCP and buccal lowest point (BLP); DBV2 (distobuccal cusp vector 2), the vector connecting DBCP and BLP; MLV2 (mesiolingual cusp vector 2), the vector connecting MLCP and lingual lowest point (LLP); DLV2 (distolingual cusp vector 2), the vector connecting DLCP and LLP; BCV (buccal cusps vector), the vector connecting MBCP and DBCP; LCV (lingual cusps vector), the vector connecting MLCP and DLCP; BP (buccal occlusal plane), the plane consisting of MBCP, DBCP, and MLCP; LP (lingual occlusal plane), the plane consisting of MBCP, MLCP, and DLCP.

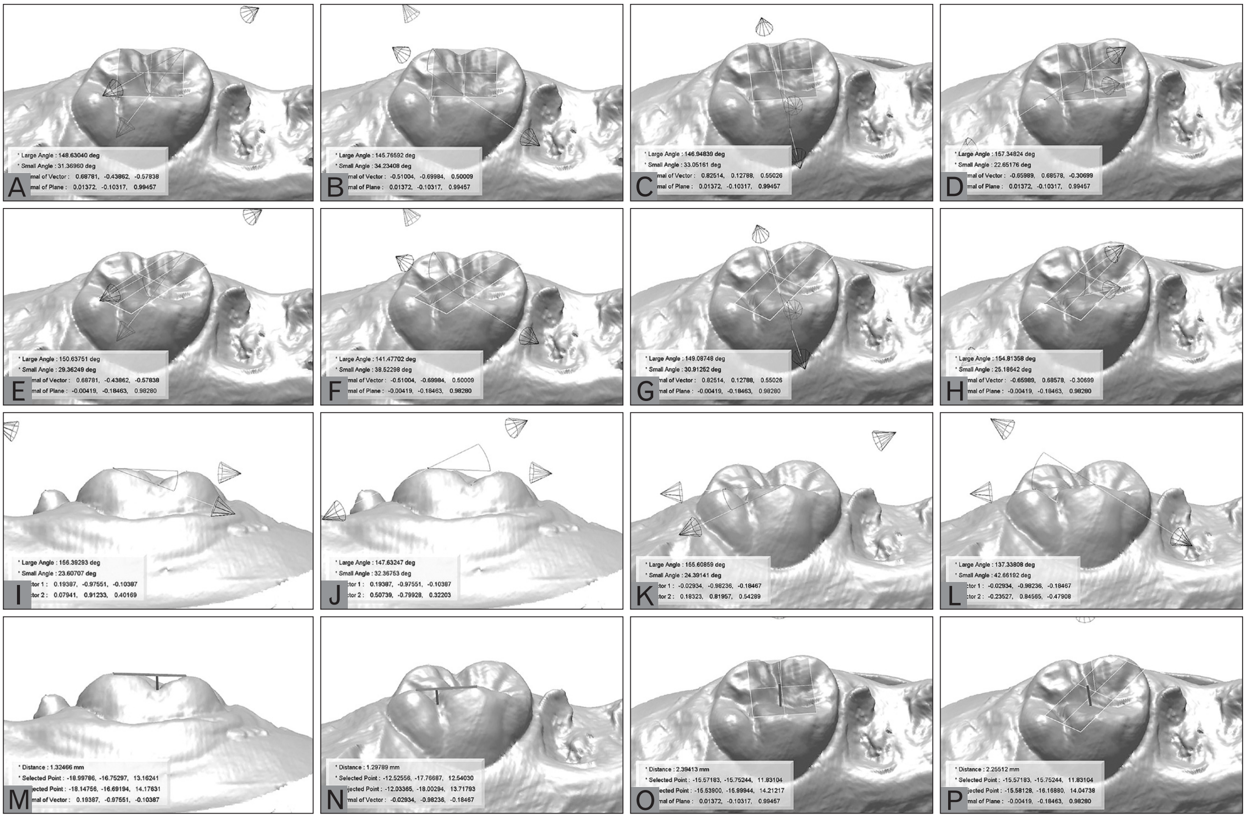

Fig. 2. Measurement parameters. (A) MBCA_BP. (B) DBCA_BP. (C) MLCA_BP. (D) DLCA_BP. (E) MBCA_LP. (F) DBCA_LP. (G) MLCA_LP. (H) DLCA_LP. (I) MBCA_BV. (J) DBCA_BV. (K) MLCA_LV. (L) DLCA_LV. (M) BCVH. (N) LCVH. (O) BCPH. (P) LCPH. MBCA_BP (mesiobuccal cusp angle with buccal occlusal plane [BP]), the angle between mesiobuccal cusp vector 1 (MBV1) and BP; DBCA_BP (distobuccal cusp angle with BP), the angle between distobuccal cusp vector 1 (DBV1) and BP; MLCA_BP (mesiolingual cusp angle with BP), the angle between mesiolingual cusp vector 1 (MLV1) and BP; DLCA_BP (distolingual cusp angle with BP), the angle between distolingual cusp vector 1 (DLV1) and BP; MBCA_LP (mesiobuccal cusp angle with lingual occlusal plane [LP]), the angle between MBV1 and LP; DBCA_LP (distobuccal cusp angle with LP), the angle between DBV1 and LP; MLCA_LP (mesiolingual cusp angle with LP), the angle between MLV1 and LP; DLCA_LP (distolingual cusp angle with LP), the angle between DLV1 and LP; MBCA_BV (mesiobuccal cusp angle with buccal cusps vector [BV]), the angle between mesiobuccal cusp vector 2 and BV; DBCA_BV (distobuccal cusp angle with BV), the angle between distobuccal cusp vector 2 and BV; MLCA_LV (mesiolingual cusp angle with lingual cusps vector [LV]), the angle between mesiolingual cusp vector 2 and LV; DLCA_LV (distolingual cusp angle with LV), the angle between distolingual cusp vector 2 and LV; BCVH (buccal cusps vector height), the shortest distance from buccal cusps vector to buccal lowest point; LCVH (lingual cusps vector height), the shortest distance from lingual cusps vector to lingual lowest point; BCPH (buccal cusps plane height), the shortest distance from BP to central pit point (CPP); LCPH (lingual cusps plane height), the shortest distance from LP to CPP.

LP, (8) distolingual cusp angle with LP (DLCA_LP): the angle between DLV1 and LP, (9) mesiobuccal cusp angle with BV (MBCA_BV): the angle between MBV2 and BV, (10) distobuccal cusp angle with BV (DBCA_BV): the angle between DBV2 and BV, (11) mesiolingual cusp angle with LV (MLCA_LV): the angle between MLV2 and LV, (12) distolingual cusp angle with LV (DLCA_LV): the angle between DLV2 and LV, (13) buccal cusps vector height (BCVH): the shortest distance from buccal cusps vector to BLP, (14) lingual cusps vector height (LCVH): the shortest distance from lingual cusps vector to LLP, (15) buccal cusps plane height: the shortest distance from BP to CPP, and (16) lingual cusps plane height: the shortest distance from LP to CPP.

Statistical analysis

First, means and standard deviations were calculated with the values from each parameter. Then, an unpaired sample t test was performed to compare the young and the adult groups. Differences in the mean values were calculated in all parameters and expressed as percentages using the young group as the standard. Also, in order to find the differences in the 4 measurements, MBCA, DBCA, MLCA, and DLCA, based on the reference plane, an unpaired sample t test was

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performed for the two groups. All statistical analyses were performed using SPSS ver. 11.5 (SPSS Inc., Chicago, IL, USA).

Results

Means and standard deviations from the 16 parameters are organized in Table 1. In all measurement parameters, there were statistically significant differences between the young and the adult groups (P<0.001). However, the changes in the amount of tooth wear were different. In order to compensate for the variations in the range of the measurements, values were expressed as percentages using the young group as the standard. Generally, the amount of tooth wear was greater when using virtual vectors (_BV, _LV, VH) compared to the measurements made from virtual planes (_BP, _LP, PH).

The results from the 4 measurement parameters, MBCA, DBCA, MLCA, and DLCA, based on the reference planes (_BP, _LP) were all statistically significant (P<0.001).

The 3 angles, MBCA_BV, DBCA_BV, and buccal cusp angle (BCA), form a triangle connected by buccal cusps and deepest points of the outline; MLCA_LV, DLCA_LV, and lingual cusp angle (LCA) form a triangle connected by lingual cusps and deepest points of the outline; and BCVH and LCVH refer to the heights of these triangles. Changes in BCA and LCA were small when a larger value was used as reference. However, the changes were similar when the reference was chosen as a smaller value, obtained by the subtraction of a larger value from 180°.

Discussion

In this study, effective quantitative measurement parameters for the comparison of Korean young and adult maxillary first molar tooth wear were evaluated. Throughout the investigation, virtual three-dimensional models were used to assess the changes in the cusp angulations.

The most common causes of tooth wear are the physical characteristics of food, including roughness, presence of abrasive particles, and toughness, and oral habits, such as chewing gum, bruxism, and excessive brushing. In addition, some minor causes consist of enamel thickness, cusp shape, root angulation, occlusion, arch shape, order of tooth eruption, and parafunctional habits [13].

Maxillary and mandibular tooth wear rates were reported to be different according to race and time period. While it has been published that maxillary teeth are worn more quickly

Table 1. Means, standard deviations, and differences of the means between groups

Parameter	Mean±SD (° or mm)		Difference of mean	Difference (%)
	Young	Adult		
MBCA_BP***	31.46±3.22	22.24±3.65	−9.22	29.32
DBCA_BP***	34.99±3.19	23.84±4.54	−11.15	31.86
MLCA_BP***	33.93±3.63	28.01±4.85	−5.92	17.44
DLCA_BP***	20.69±2.33	15.72±5.08	−4.98	24.05
MBCA_LP***	28.53±3.50	20.21±3.92	−8.32	29.15
DBCA_LP***	40.83±4.17	27.51±5.63	−13.32	32.63
MLCA_LP***	30.65±3.41	25.33±4.91	−5.32	17.36
DLCA_LP***	23.62±2.00	18.55±3.36	−5.07	21.45
MBCA_BV***	24.60±3.35	13.65±3.28	−10.95	44.50
DBCA_BV***	28.88±2.97	17.51±7.24	−11.37	39.37
MLCA_LV***	20.84±3.55	11.51±4.85	−9.34	44.79
DLCA_LV***	37.99±5.97	21.55±10.56	−16.43	43.26
BCA***	126.52 (53.48)±3.62	148.84 (31.16)±8.32	22.32	17.64 (41.73)
LCA***	121.17 (58.83)±8.64	146.94 (33.06)±13.54	25.77	21.27 (43.80)
BCPH***	2.39±0.17	1.78±0.29	−0.60	25.28
LCPH***	2.18±0.19	1.62±0.30	−0.56	25.57
BCVH***	1.27±0.16	0.64±0.20	−0.63	49.64
LCVH***	1.11±0.19	0.63±0.26	−0.48	43.51

MBCA_BP, mesiobuccal cusp angle with buccal occlusal plane (BP); DBCA_BP, distobuccal cusp angle with BP; MLCA_BP, mesiolingual cusp angle with BP; DLCA_BP, distolingual cusp angle with BP; MBCA_LP, mesiobuccal cusp angle with lingual occlusal plane (LP); DBCA_LP, distobuccal cusp angle with LP; MLCA_LP, mesiolingual cusp angle with LP; DLCA_LP, distolingual cusp angle with LP; MBCA_BV, mesiobuccal cusp angle with buccal cusps vector (BV); DBCA_BV, distobuccal cusp angle with BV; MLCA_LV, mesiolingual cusp angle with lingual cusps vector (LV); DLCA_LV, distolingual cusp angle with LV; BCA, buccal cusp angle; LCA, lingual cusp angle; BCPH, buccal cusps plane height; LCPH, lingual cusps plane height; BCVH, buccal cusps vector height; LCVH, lingual cusps vector height. ***P<0.001.

[14], the amount of tooth wear and dentin exposure are known to be greater in the mandible compared to the maxilla [15, 16]. Also, there were studies that presented differences in gender according to race and time period. Some suggested that tooth wear can occur faster in males because of work-related stress or use of their teeth as tools [17-19]. On the other hand, other research reported various differences among genders [14]. According to anthropometric studies, anterior tooth wear developed earlier horizontally compared to posterior teeth when hunting was the predominant source of food, and since the agrarian society, tooth wear characterized by inclinations and concavity was commonly present in the posterior teeth [20].

Qualitative method of evaluating tooth wear has the advantage of directly observing the oral cavity without the use of special equipment, making the analysis simple and quick. However, various attempts have been made to quantify tooth wear which would not have been possible with the qualitative method. Multiple analyses with different instruments can be carried out through the indirect method of using a dental model. One example would be cusp height measurement, which was done by utilizing depth gauge with a small ball tip [19], determining the distance from cervical line to cusp tip [21], or using a combination of moiré pattern and digital image [22]. Also, Leinfelder et al. [5] suggested utilizing reference models, compensated to have tooth wears at 0.1 mm intervals, for the comparison measurement of the amount of vertical wear. However, some of the disadvantages of these methods are that the depth gauge is affected by the size of the ball, and there needs to be an extracted tooth in the case of measuring cusp height from the cervical line. In addition, using reference models depends on the subjective judgment of the observer, which will reduce the measured quantities. There was an experiment by Butler [23] that attempted measuring cusp angulation using a plastic protractor. However, it was reported that the result was significantly affected by the observer's subjective judgment in aligning the model with just a minor movement. In order to overcome these problems, we have been consistently using virtual three-dimensional models to analyze tooth or dental restorative material wear and evaluate effective measurement parameters. The most valid method in quantifying tooth wear is the determination of the change in volume, through which the advantages of the three-dimensional model can be utilized [3]. In other words, this research is possible in longitudinal experimental models evaluating the change in volume with time using a reference model of a single subject, but it is not a practical application for multiple subjects. Therefore, the effectiveness of tooth wear measurement parameters, such as distance, height, and angle, was investigated, and good results were achieved for the height and the angle parameters. Based on the outcome, existing angle parameter was revised to develop new parameters, and it was confirmed that there was statistically significant difference between the young and the adult groups in all parameters.

Two lines in the same plane are drawn from a point to form an angle, and three-dimensional models are created where a vector and a plane, and two planes meet. In this study, various angles formed from virtual planes and vectors were measured, through which tooth wear patterns of buccal and lingual cusps were evaluated. In addition, parameters with statistical significance from a previous research were measured. In this earlier study, the vector distances from central pit to each cusp tip did not uniformly change, so this measurement parameter was considered to be insignificant [12]. However, measurement of the angle formed between this vector and plane showed statistically significant differences between the young and the adult groups. In general, tooth wear was slightly greater on buccal and distal cusps, indicated by a decrease in angle due to cusp height reduction.

Among the age groups, there was a large change in angles (_BV or _LV) which were measured based on the vectors connecting buccal and lingual cusps. For BCA and LCA, when a smaller angle measurement was used as the reference, there was more than 40% change in the values for MBCA_BV, DBCA_BV, MBCA_LV, and DBCA_LV, and a large amount of change was also seen in the height parameters, BCVH and LCVH. The reason for the smaller amount of change measured from the virtual planes may be due to the possibility of wear in the central pit, since all parameters were measured using that reference point. Rather, because the cusp wear occurred three-dimensionally, it could be predicted that measuring from the same plane of the triangle resulted in smaller values. Thus, for more effective measurement, appropriate parameter needs to be chosen based on the vector connecting buccal and lingual cusps. However, there should also be a consideration for the large standard deviations in the adult group which could be caused by individual difference. Because the amount of wear in young group was little but it was large in adult group and there was no data regarding detailed occlusion status or dietary habit of individuals. Therefore, more detailed analysis would be performed with

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detailed individual information in the next study.

In addition, all parameters showed statistically significant differences when separate measurement parameters (BP and LP) from the same vector were used. These two planes were selected based on the two of the three points forming a plane on the mesial (MBCP, MLCP) and the remaining point in the distobuccal and distolingual region (DBCP, DLCP). By just looking at this result, selection of the plane seems to significantly affect the outcome. However, except DLCA, the amounts of change of the three angles were all similar when examining the values indicated as percentages. Therefore, it is considered that using any planes of the parameters, excluding DLCA, will not affect the result.

First molars are worn faster than second molars [24], mainly due to attrition or abrasion. Attrition occurs between maxillary and mandibular teeth, and abrasion occurs between maxillary or mandibular teeth and food and is consistently observed during meals or normal function. Mastication process can be broadly divided into three phases: preparatory, crushing, and grinding [25]. The ingested food first makes contact with teeth in the preparatory phase. When the food is broken down through the crushing phase, there is eccentric contact between maxillary and mandibular teeth. In the grinding phase, the teeth move into centric occlusion, leading to tooth-to-tooth contact; in other words, tooth wear occurs [3]. During this process, buccal and lingual cusps of the maxillary teeth are categorized into non-functional and functional cusps, respectively. Even though the results of this study depend on whether the reference is plane or vector, it was confirmed that there was wear in both buccal and lingual cusps. As shown in the previous studies [26, 27] demonstrating that unilateral mastication occurs both in functional and non-functional cusps, tooth wear occurs bilaterally in both cusps throughout everyday life. Therefore, care should be taken when removing non-functional contact during occlusal adjustment of a restoration [26].

Regarding limitation of this research,

This study has examined various measurement parameters for tooth wear analysis. In order to evaluate the effectiveness of the parameters, amount of tooth wear was expressed as percentages. Through comparison of the percentage values, it was confirmed that the changes in angles based on the vectors connecting buccal and lingual cusps were large. As these new measurement parameters are proven to be effective on the quantification of tooth wear, it can also be applied to the study of dental restorative material wear, which is another common problem in clinical dentistry. Similar to teeth, wear of dental biomaterials are also significantly affected by various extrinsic factors, such as the type of opposing material and patient's oral habits [3], and selection of a dental restorative material that can tolerate these external causes is critical. Therefore, evaluation of the dental restorative material wear with the new measurement parameters can assist clinicians in choosing the most appropriate material. Even though this study evaluated only the maxillary arch regardless of gender, further investigations of the mandibular arch with different time periods and gender and how diet and cultural impact will affect tooth wear are warranted.

Total of 40 dental casts from 20 first- or second-grade elementary school students (7.57±1.55 years old) and 20 adults aged 20 and older (56.85±6.34 years old) were used.

Means and standard deviations were calculated with the values from each parameter, and an unpaired sample t test was performed for the comparison of the young and the adult groups. Differences between the means were determined in all parameters and were expressed as percentages using the young group as the standard. Also, differences in the measured values according to the parameters were confirmed to conclude the following:

(1) In all measurement parameters, there was statistical significance between the young group and the adult group ($P<0.001$). (2) There was difference in the amount of change according to each parameter. Overall, the amount of change measured using vectors (_BV, _LV, VH) was greater than the amount of change measured using planes (_BP, _LP, PH). (3) The differences evaluated according to the parameters measured from planes (_BP, _LP) showed statistical significance ($P<0.001$). However, the changes in the values of the three angles, excluding DLCA, were similar. (4) Based on these results, the effective measurement parameters were confirmed, and it was concluded that tooth wear took place in both buccal and lingual cusps.

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