Assessment of occlusal tooth wear in sports players

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Assessment of occlusal tooth wear in sports players

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The Master's Thesis

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This certifies that the Master's Thesis

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감사의 글

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이 조그마한 기쁨을 제가 사랑하는 그리고 저를 사랑해주시는 모든 분들과 함께 나누고 싶습니다. 특히 소중한 저의 동료와 선후배 그리고 보철과 식구에게 깊은 감사를 드립니다. 마지막으로 오늘의 제가 있기까지 무한한 조언, 격려, 위로 그리고 사랑을 베풀어주신 아버지, 어머니, 언니에게 모든 영광을 돌립니다.

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이소진 드림

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ABSTRACT

Assessment of occlusal tooth wear in sports players

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Objectives: The aim of this study is to investigate whether contact sports affect attrition, by comparing and analyzing the degree and quantity of attrition in sports major students to those of non-sports major students.

Materials and methods: Thirty sports major students and thirty non-sports major students participated in this study. Maxillary and mandibular dental casts were fabricated and were assessed by Hooper's new tooth wear index to grade the degree of attrition. The casts were also digitally scanned and rendered as three-dimensional virtual models to measure the quantity of attrition. A questionnaire was prepared to investigate the correlation between attrition and its various potential factors. Independent t-test, Fisher's exact test and linear correlation were used and teeth were grouped by tooth type (molars, premolars, canines and incisors), by dental arch (maxillary and mandibular arch) and by total dentition for statistical analysis.

Results: Sports major students revealed significantly higher Hooper's new tooth wear index scores for maxillary premolars and incisors, and mandibular molars, premolars and incisors in comparison to the non-sports major students. Mandible of the sports major students presented substantially higher score for the Hooper's new tooth wear index score per dental arch. Sports major students displayed significantly higher in quantity of attrition for maxillary molar, mandibular molar, premolar and canine. Furthermore maxilla, mandible and total dentition of the sports major students were all substantially higher in quantity of attrition. The demographic data revealed that sports major students were significantly younger in age, heavier in weight, and more aware of their attrition status than the non-sports major students.

Conclusion: Within the limitations of this study, the following conclusions were made:

1. Contact sports affect the degree and quantity of attrition.
2. Sports major students present significantly higher degree of attrition with Hooper's new tooth wear index than non-sports major students.
3. Sports major students present significantly larger quantity of attrition when measuring the attrition surface area than non-sports major students.

Keywords: sports, attrition, virtual models, degree, quantity

Assessment of occlusal tooth wear in sports players

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I. INTRODUCTION

Considerable orofacial injury risk is involved in playing sports [1-3]. Contact sports such as rugby and ice hockey are sports in which players physically interact with each other [4]. Much attention has been drawn to these sports because of their higher risk of dentoalveolar injuries compared to non-contact sports [3, 5]. The majority of contact sports-related studies thus focus on the prevention of such injuries using mouthguards [3, 4, 6]. These studies, however, rarely recognize other irreversible dental changes such as tooth wear, especially attrition. Attrition is the wear of the occlusal and incisal tooth surfaces by direct tooth-to-tooth friction [7]. Sports players are more susceptible to attrition because they have higher prevalence of clenching than non-sports players [8, 9]. Sports players usually clench their teeth when they attempt to exert physical force. Clenching not only influences the maximal grip strength generation but also the rapidity of grip force production [10]. Thus such repetitive clenching action increases the frequency and duration of direct tooth-to-tooth contact, resulting in attrition.

Tooth wear is classified as attrition, abrasion and corrosion [7]. They are identified by thorough case history, such as general health, oral parafunction (clenching, bruxism),

habits (biting on foreign objects), dietary habits (mastication of hard and resistant or, consumption of carbonated drinks or acidic beverages) and environmental factors (occupational exposure to industrial gases, wind instrument player). Their status are examined by intraoral clinical examination, radiographs and dental casts [11]. The mechanisms behind the three types of tooth wear can act independently, simultaneously, alternately or sequentially, thus complicating the differential diagnosis [12]. The main etiologies behind attrition are deglutition and parafunction such as bruxism and clenching [7] and its major clinical manifestations are the polished facet on the molar cusp or ridge, or flattening of the incisal edge [12]. Enamel and dentin are gradually lost simultaneously with the increase of facet number, until an advanced wear stage is reached when facets start to fuse and cusp heights are reduced [13]. In heavily worn teeth, there are no facets identifiable but a large flat dentin base, resulting in occlusal plane flattening [12, 13]. It is therefore important to diagnose tooth wear at an early stage, attrition in the case of sports major students, in order to prevent progressive and extensive wear, and avoid complex restorative treatment in the future [14].

The most popular and conventional method in clinically diagnosing attrition is by using tooth wear index (TWI) [15-19]. Many TWIs are available to grade the degree of tooth wear. They are generally based on analyzing tooth substance loss, in relation with degree of worn enamel, size of exposed dentin and reduction in clinical crown length [11]. The advantages of these conventional approaches are that they are simple, readily available and do not require special equipment [20]. Nevertheless there is no consensus for a universally applicable index because the existing indices all present certain limitations. TWIs are low in sensitivity for initial and minimal wear changes, and no clear classification and quantification exist for wear of restored, filled or carious tooth and its opposing dentition [20]. Furthermore, subjective evaluation is inevitable which necessitate training and calibration to establish data reliability [21, 22]. Therefore, in attempt to overcome the weakness of such scoring method, several authors have attempted to investigate the quantity of attrition. At present, three-dimensional measuring techniques are actively being utilized. Virtual dental models are reconstructed with the use of three-dimensional scanners and specialized software. The accuracy and reliability

of these models for dental analysis have been demonstrated and these models can provide extensive information [20, 22-26].

The aim of this study is to investigate whether sports affect attrition, by comparing and analyzing the degree and quantity of attrition in sports major students to those of non-sports major students.

II. MATERIALS AND METHODS

Thirty sports major students of Yonsei University (average=20.30yr, range 19-22) and thirty non-sports major students of Yonsei University (average=23.10yr, range 22-26), all male, were selected, meeting the criteria of full or nearly-full natural dentition. The thirty sports major students were all contact sports players (fourteen rugby players, sixteen ice hockey players) and thirty non-sports major students, selected as the control group, had no previous experience of professional athleticism. Standard clinical examination was performed beforehand to exclude subjects on orthodontic or prosthodontics treatment, subjects with more than four heavily restored teeth or more than four missing teeth, or subjects with temporomandibular joint disorder or myofascial pain.

A set of maxillary and mandibular dental impression was taken using plastic tray (DentiAnn™ TRAY, Seil global, Busan, South Korea) and polyether (Impregum™ Penta™, 3M ESPE, St.Paul, Minn. USA) (Figure 1-A.). A set of casts was fabricated using vacuum-mixed type IV dental stone (Hera Moldastone CN, Heraeus, Hanau, Germany) according to the manufacturer's instruction. After setting of the gypsum, the cast was trimmed to a horse-shoe shape and fixed to plaster base (Neo Gemma 70, Samwoo Co., Ltd., Ulsan, South Korea) of 15mm uniform thickness using a silicone mold (Figure 1-B., 1-C.). Impressions were retaken and new casts were fabricated when casts demonstrated deformation or low definition.

1-A. 1-B. 1-C.

Figure1. Fabrication of dental cast

1-A. Impressing taking of the mandible using plastic stock tray and polyether

1-B. Dental cast of type IV dental stone, trimmed to a horse-shoe shape

1-C. Dental cast with a base of 15mm uniform thickness using plaster

All natural teeth were evaluated for attrition. Heavily decayed or restored tooth (loss of more than two cusps), prosthesis, antagonist tooth to a heavily restored or prosthesis, and the third molar were excluded from the evaluation.

This study was approved by the institutional review board of School of Dentistry, Yonsei University [IRB No: 2-2012-0056].

1. Preparation of three-dimensional virtual models

Dental casts were scanned by DScan (E.G.S., San Lazzaro di Savena, Italy), a three-dimensional scanner. DScan has an accuracy of ±0.010mm, a point distance of 0.04mm and scans a cast in 16 different axes. The images of each cast are combined and rendered as three-dimensional model (Figure 2) with DentalCAD (E.G.S., San Lazzaro di Savena, Italy) which are then analyzed with Rapidform™XOR/Redesign software (INUS Technology, Seoul, South Korea).

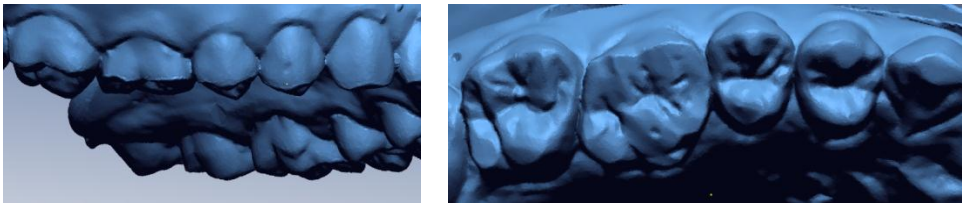

Figure 2. Buccal and occlusal view of the virtual model (maxillary right quadrant)

2. Grading degree of attrition

Grading of degree of attrition was performed by one trained observer (S.L.) on the dental casts after a period of evaluation training. The casts were assessed under one lighting condition. Hooper's new tooth wear index (NTWI) [27], a modified index of

Smith and Knight tooth wear index (TWI) [15], was used for grading the incisal and occlusal teeth wear, as outlined in Table 1.

Table 1. Hooper's new tooth wear index

	0	1	2	3	4	5
Incisors	No wear	Loss of mamillons	Part but not all of incisal edge	Entire incisal edge worn with up to 1/6 crown height reduction	Incisal height reduced by a 1/6 but <1/3 crown height	Incisal height reduced by 1/3 crown height
Canines	No wear	Normal appearance with just definable wear	Faceting <1/3 diameter of M-D width at base of cuspal slopes	Faceting <1/3 and up to 2/3 of diameter of M-D width at base of cuspal slopes	Faceting >2/3 of diameter of M-D width at base of cuspal slopes	Canine height lost beyond base of cuspal slopes
Premolars and molars	No wear	Normal appearance with just definable wear	Faceting of any or all natural cusps<1/3 cusp width at base of cuspal slopes	Faceting of any or all natural cusps>1/3 and up to 2/3 of diameter of M-D width at base of cuspal slopes	Faceting of any or all natural cusps>2/3 of diameter of M-D but <width of M-D cuspal base	Completely flattened occlusal surface

M-D, mesio-distal

3. Measuring quantity of attrition

The wear facet areas were obtained for the canines, premolars and molars. The incisors were excluded from the measurement due to the difficulty in discerning a definite boundary between the incisal wear facet and the marginal ridge. The wear facets on the virtual models of the canine, premolar and molars could be easily detected (Figure 3). To reinforce the exactitude, the wear facets on the virtual models were compared to those on

the dental casts. By using Rapidform™XOR/Redesign software (INUS Technology, Seoul, South Korea), the boundary of all the wear facets were independently marked, and the surface areas within the boundary were calculated in millimeter square (mm^2) to four decimal points. To allow comparison of measurement of quantitative wear amongst subjects and to compensate for the different tooth size amongst subjects and to, the percentage of the wear facet to the total tooth area was calculated for each tooth.

Total tooth area encompasses all scanned tooth surfaces. The majority of the mesial and distal proximal surfaces are obscured because of the contact areas, except for the distal surfaces of the second maxillary and mandibular molars or teeth with spacing. To unify the measuring method and normalize the measurement result, the proximal areas were all excluded from the measurement. Therefore only the buccal, occlusal and palatal/lingual surfaces were measured. The reference boundaries for buccal and palatal/lingual surfaces were the mesiobuccal, distobuccal, mesiopalatal/lingual, distopalatal/lingual line angles, and the cervical lines formed by the tooth and the gingiva. The reference boundaries of occlusal surface were the mesio-occlusal, disto-occlusal, linguo-occlusal and disto-occlusal line angle.

Figure 3. Occlusal view of virtual model (maxillary right premolar and canine)

4. Subject assessment using questionnaire

A questionnaire was designed based upon review of the literature [20, 28, 29] and clinical experience. Its purpose was to investigate the correlation between attrition and its various potential factors. The questionnaire included demographic data such as age(year),

height(cm), weight(kg) and clinical data such as awareness of attrition (no wear, slight wear, moderate wear, severe wear), clenching (yes, no), bruxism (yes, no), and amount of drinking (average number of beer can drunk per week) and smoking (average number of cigarette smoked per week).

5. Statistical analysis

The mean and standard deviation of degree and quantity of attrition were calculated by grouping per tooth type (molars, premolars, canines and incisors), per dental arch (maxillary and mandibular arch) and by total dentition (sum of all the maxillary and mandibular teeth). The data was analyzed with t-test at a 5% probability level.

Difference in potential variables of attrition such as age, weight, height, the amount of drinking and smoking per week between sports major and non-sports major students were analyzed with t-test at a 5% probability level. The difference in awareness of attrition, clenching and bruxism were analyzed with Fisher's exact test at a 5% probability level. Linear correlation coefficient was calculated to assess the correlation between total amount of attrition and the above mentioned factors.

The statistical software SAS® 9.2 for Windows (Released in March 2008, SAS Institute Inc., NC, USA) was used to generate descriptive statistics and perform inferential tests.

III. RESULTS

As a result of previously defined exclusion criteria, the total number of teeth analyzed per tooth type by the two groups was different (Table 2) and the mean number of teeth per sports major students was 26.23 (range of 21-28) and per non-sports major students was 26.83 (range of 23-28).

Table 2. Total number of teeth analyzed after exclusion

Group	Maxilla				Mandible			
	M	PM	C	I	M	PM	C	I
Sports major students								
	101(120)	113(120)	60(60)	57(60)	102(120)	115(120)	59(60)	56(60)
Non-sports major students								
	110(120)	110(120)	59(60)	60(60)	108(120)	111(120)	60(60)	58(60)

M=molar, PM=premolar, C=canine, I=incisor, ( ) = initial number of teeth before exclusion

Sports major students revealed significantly higher Hooper's NTWI scores for maxillary premolars and incisors, and mandibular molars, premolars and incisors in comparison to the non-sports major students (Table 3).

Table 3. Hooper's new tooth wear index per tooth type

Group	Maxilla				Mandible			
	M	PM	C	I	M	PM	C	I
Sports major students								
Mean	3.68	3.34	3.60	2.36	3.93	3.19	3.48	2.57
SD	0.41	0.55	0.70	0.53	0.17	0.64	1.01	0.55
Non-sports major students								
Mean	3.61	2.80	3.52	1.99	3.75	2.66	3.10	1.96
SD	0.42	0.68	0.61	0.27	0.29	0.84	0.87	0.36
P-value[a]	0.5866	0.0027*	0.6245	0.0022*	0.0280*	0.0110*	0.1255	<0.0001*

M=molar, PM=premolar, C=canine, I=incisor, SD=standard deviation

[a] independent t-test, * Significant levels between the testing groups

Mandible of the sports major students presented substantially higher score for the Hooper's NTWI score per dental arch (Table 4).

Table 4. Hooper's new tooth wear index per dental arch and total dentition

Group	Maxilla	Mandible	Total dentition
Sports major students			
Mean	3.14	3.29	3.23
SD	0.37	0.32	0.34
Non-sports major students			
Mean	2.97	2.85	2.91
SD	0.24	0.33	0.26
P-value[a]	0.1316	0.0011*	0.0055

SD=standard deviation, [a] independent t-test, * Significant levels between the testing groups

Sports major students displayed significantly higher in quantity of attrition for maxillary molar, mandibular molar, premolar and canine (Table 5). Furthermore maxilla, mandible and total dentition of the sports major students were all substantially higher in quantity of attrition (Table 6).

Table 5. Quantity of attrition per tooth type

Group	Maxilla			Mandible		
	M	PM	C	M	PM	C
Sports major students						
Mean (%)	16.49	8.57	9.36	16.58	7.05	6.51
SD	0.05	0.03	0.04	0.05	0.02	0.02
Non-sports major students						
Mean (%)	13.58	7.20	7.93	13.11	5.57	5.12
SD	0.04	0.03	0.03	0.05	0.02	0.02
P-value[a]	0.0202*	0.1023	0.1134	0.0119*	0.0216*	0.0218*

M=molar, PM=premolar, C=canine, SD=standard deviation

[a] independent t-test, * Significant levels between the testing groups

Table 6. Quantity of attrition per dental arch and total dentition

Group	Maxilla	Mandible	Total dentition
Sports major students			
Mean	11.47	10.05	10.76
SD	0.03	0.03	0.03
Non-sports major students			
Mean	9.57	7.93	8.75
SD	0.02	0.02	0.02
P-value[a]	0.0132*	0.0009*	0.0017*

SD=standard deviation, [a] independent t-test, * Significant levels between the testing groups

Age, weight, height, drinking, smoking, awareness of attrition, clenching and bruxism were analyzed to investigate the difference in potential variables of attrition between the sports major students and non-sports major students (Table 7). The demographic data revealed that sports major students were significantly younger in age (average=20.30 range 19-22), heavier in weight (average=86.10kg, range 68.00-111.80), and more aware of their attrition status than the non-sports major students (average age=23.13, age range 22-26, average weight=67.60kg, weight range 57.00-95.00). The correlation between the total quantity of attrition and age, weight, height and awareness of attrition were of significance. There was no significant difference in height, amount of drinking or smoking, awareness of clenching and bruxism between the sports major students and non-sports major students.

Table 7. Difference in potential variables between sports major and non-sports major students

Variables	P-value
Demographic data	
Age	<0.001[a]*
Weight	<0.001[a]*
Height	0.0177[a]*
Drinking	0.1435[a]
Smoking	0.0476[a]
Awareness of	
Attrition	0.0004[b]*
Clenching	0.5058[b]
Bruxism	0.5653[b]

[a] independent t-test, [b] Fisher's exact test, * Significant levels between the testing groups

Of the 8 variables investigated for correlation between the total quantity of attrition and age, weight, height and awareness of attrition were of significance (Table 8). Drinking, smoking, awareness of clenching and bruxism were not statistically significant.

Table 8. Correlation between total amount of attrition of all students and the potential variables

Variables	R	P-value[a]
Demographic data		
Age	-0.2604	0.0445*
Weight	0.3960	0.0017*
Height	0.3053	0.0177*
Drinking	-0.1911	0.1435
Smoking	-0.2568	0.0476
Awareness of		
Attrition	0.4436	0.0004*
Clenching	0.0856	0.5058
Bruxism	0.0757	0.5653

R= linear correlation coefficient, [a] independent t-test

* Significant levels between the testing groups

IV. DISCUSSION

In the systematic review investigating the prevalence of tooth wear, Van't Spijker et al [30] reported that Smith and Knight TWI or modified TWIs are most commonly used indices. Smith and Knight TWI is simple and easy to understand but it is an entirely clinical approach index, relying on the clinician's estimation. It requires the clinician to estimate the size of exposed dentin and determine whether the exposed dentin is secondary or not, which is difficult to apply without bias [21]. Another commonly used index is the one proposed by Johansson et al [19] which ranges from a scale from 0 to 4. This index is more detailed than Smith and Knight TWI. It attempts to quantify 'altered morphology (grade 1)', 'extensive wear' (grade 2) and 'substantial loss of crown height' (grade 3), and requires taking intraoral photographs to distinct secondary dentin from primary dentin (grade 4) [19, 21]. Similar limitations arise with Johansson scale as with Smith and Knight TWI in that the terms such as 'extensive' and 'substantial' are open to subjectivity and that even with photographs it is difficult to discern secondary dentin from primary dentin [21]. Therefore assessment of attrition using indices alone is insufficient [31].

In the present study, dental casts of 30 sports major students and 30 non-sports major students were fabricated to detect small wear facets that could not be detected during clinical examination, to grade the degree and to quantify attrition. Impression was taken with polyether (Impregum™ Penta™, 3M ESPE, St.Paul, Minn. USA) instead of alginate due to its better ability to reproduce fine detail of less than 25㎛ [32]. Pouring with vacuum-mixed type IV dental stone (Hera Moldastone CN, Heraeus, Hanau, Germany) was preformed within one hour of removal from the mouth, as recommended by the manufacturer, to maximize dimensional stability [33]. Formation of few positive voids was inevitable during the impression taking, which were later on removed from the casts.

Hooper's NTWI, an index suitable for analyzing dental casts [22], was used in this study to assess the degree of attrition. In previous studies, repeatability of this index was evaluated, and it presented good agreement for intra and inter-observers [22, 27].

Loss of occlusal and incisal surface contours are classified in a simple and objective manner, and the six scores ranging from 0 to 5 are allocated to each tooth. Hooper proposes the analysis of the proportion of the faceting area to the mesio-distal width at base of cuspal slope or the proportion of loss of crown height [27]. This is an easier approach than estimating the relative surface area of the exposed dentin on the occlusal surface, as required by TWI, because the exposed dentin is usually irregularly shaped or fragmentary [21].

The areas of wear facets on the virtual model were calculated to quantify attrition. By clinical experience and as stated in previous studies [13, 22, 34], marking of the wear facets on the dental casts was not difficult and they were outlined with a sharp pencil (HB 0.5mm). The traced wear facets, however, couldn't be detected by the scanner, thus failing to appear on the virtual model. Several alternatives, such as coloring the wear facets with a pencil, marker or paint were attempted in this study, but they were all unsuccessful. Therefore the process of marking the wear facets was repeated on the virtual model. Although the traced wear facets on the dental casts were observed when tracing the wear facets in the virtual models, inherent subjectivity couldn't be avoided because the boundaries of virtual models wear facets are not as sharp as those on the dental casts. To measure the area of attrition, Van't Spijker et al [34] used a flat-bed scanner which can detect pencil tracings. The advantage of this method is that re-tracing on the scanned models is unnecessary, but the limitation of this scanner is that wear facets that are not perpendicular to the scanning table are depicted smaller than the actual surface areas on the cast [34]. Despite the limitation as mentioned above and the time-consuming procedure, measuring the actual areas of wear facets is relatively more objective than grading with an index. However, tooth of the same type varies in size amongst subjects so the entire tooth surface area of each tooth was also measured to calculate the percentage of attrition amount per tooth. Percentage allows standardization and comparison of the results amongst subjects.

Absolute comparison between the results of Hooper's NTWI (Table 3, 4) and quantity of attrition (Table 5, 6) is impossible, yet the attrition tendency of the sports major and non-sports major students could be understood.

When comparing the results of Hooper's NTWI and quantity of attrition in Table 3 and 5, the tooth type in the maxilla that presented statistical significance is contrasting, whereas the mandibular molar and premolar are the common tooth type that presented statistical significance. For the quantity of attrition, the sports major students' maxillary molar, and for Hooper's NTWI, the sports major students' maxillary premolar and incisor presented significantly higher results than non-sports major students. Two types of underestimation in Hooper's NTWI score can be the explanation behind this finding. Firstly, Hooper's NTWI does not take into consideration the bucco-palatal length of the wear facet. The index is scored based on the proportion of wear facet's mesio-distal width to the total mesio-distal width at the base of cuspal slope for the canine, premolar and molar. In other words, same grade can be scored for the wear facet of equal width but different length. Maxillary molar and premolar have the morphologic characteristics of mesio-distal width being proportionally smaller than the bucco-palatal length. The probability of underestimation, especially in the maxillary teeth than in the mandibular teeth, increases when being assessed by Hooper's NTWI. Secondly, Hooper's NTWI only assesses the wear facets on the occlusal surface, whereas when measuring the quantity of attrition the wear facets on the buccal, occlusal and palatal/lingual surfaces are all included. For the above mentioned two reasons, underestimation of the results when using Hooper's NTWI seems inevitable.

Several studies have demonstrated that the proportion of occlusal force and occlusal contact surface area increase on the molar region compared to the premolar and anterior region with the increase in clenching intensity [35-37]. Similar phenomenon can be observed in this study. Maxillary and mandibular molars of both the sports and non-sports major students all demonstrate a higher degree and amount of attrition than premolar, canine and incisors (Table 3, 5). Furthermore, although the sports major students' maxillary premolar and incisors are of significant difference compared to non-sports major students in Hooper's NTWI (Table 3), the two scores are insufficient to reach the level of significance for the maxilla as an arch (Table 4). By contrast, the sports major students' maxillary molar is the only tooth type of statistical significance in the quantity of attrition (Table 3), but it is sufficient enough to reach the level of significance for the

maxilla as an arch (Table 6). From such difference, it can be deduced that attrition in molar is critical to the total amount of attrition.

In the present study, a questionnaire concerning the subject's age, height and weight are used to find the association between demographic data and attrition. The outcome was the sports major students being significantly younger in age and heavier in weight than non-sports major students (Table 7). Regarding weight, it can be interpreted that inherent physical condition can induce attrition but regarding age, it can interpreted that sports affect attrition. Despite the younger average age, sports major students demonstrated significantly higher quantity of attrition of the total dentition than non-sports major students (Table 6). This is an opposite finding to that of several studies which demonstrate that tooth wear is a common clinical finding that increases with age [30, 38].

Furthermore, through the correlation result (Table 8), it can be assumed that neither the sports major students nor the non-sports major students are aware of clenching and bruxism, the plausible causes of attrition, but that both groups are conscious of their attrition status. Attrition is a phenomenon that can be observed by the subject himself, by family or close friends, or could have been informed by a dentist in the past. On the other hand, presence of clenching and bruxism cannot be accurately detected because they are of subconscious parafunction [39]. The limitation to this questionnaire is that it required to answer with a simple yes or no, and did not further question reason behind the awareness of attrition, clenching and bruxism. Furthermore, if the presence of attrition was detected by the subject himself but told by another person, bias exists in the result of awareness.

The questionnaire also investigated if the subject was left or right handed, and whether he used a mouthguard. It would have been interesting to compare the attrition tendency between left and right handed sports major students, but the analysis was excluded from this study due to the imbalance in left handed sports major students (n=2) to right handed sports major students (n=28) and limited of number of subjects. Though ten sports major students were using mouthguards, the period of use ranging from one to three years, all of them infrequently used their mouthguards due to discomfort, difficulty in breathing or bulkiness. Therefore these ten sports major students were not excluded from the study.

Several limitations arise in this study. Firstly, this study is limited by its cross-sectional nature. If a series of data were used to analyze the progression in degree and quantity of attrition with a larger sample size, the evaluation would be more meaningful. Secondly, this study is limited by the university sports major students. It would be interesting to further conduct such study to professional sports players, and compare the attrition of non-contact to contact sports players. Thirdly, intra- or inter-observer grading of the degree and quantifying attrition was not conducted in this study. To reinforce the reliability and reproducibility of these two methods, intra- or inter-observer grading must be supplemented in the future study.

It is irrevocable that the trueness and precision of the digital impression compared to conventional impression still require improvement [40, 41]. With the developing technology of direct intraoral scanner, there is the potential for enhanced accuracy and decreased number of procedures compared to the method of scanning dental casts [20]. Although this study has proven that three-dimensional virtual models are applicable in the quantification of the attrition and useful for modern dentistry, there isn't any suggested standardized method or a consensus on the method quantifying attrition with virtual models. With the dropping of the three-dimensional scanner cost and the increased availability of scanning services [20], studies on the measurement of quantitative attrition and its standardization may increase in the near future.

V. CONCLUSION

Within the limitations of this study, the following conclusions were made:

1. Contact sports affect the degree and quantity of attrition.
2. Sports major students present significantly higher degree of attrition with Hooper's new tooth wear index than non-sports major students.
3. Sports major students present significantly larger quantity of attrition when measuring the attrition surface area than non-sports major students.

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ABSTRACT (in Korean)

운동 선수의 치아 교합면 마모도에 대한 조사

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연구 목적: 본 연구는 운동 전공 학생과 비운동 전공 학생들의 치아 교모의 정도와 양을 비교 분석하여, 운동이 치아 교모에 영향을 미치는지 조사하고자 한다.

실험 방법: 30명의 운동 전공 학생과 30명의 비운동 전공 학생들을 대상으로 인상 채득을 하여 상하악 모형을 제작하였다. 교모의 정도를 평가하기 위해 Hooper’s new tooth wear index로 치아 모형을 분석하였고, 교모의 양을 평가하기 위해, 치아 모형을 삼차원적으로 스캐닝을 시행하여 삼차원적 가상의 모형에서 교모된 면적을 계측하였다. 설문지를 통해 치아 마모와 여러 가지 잠재적인 요인들과의 연관성을 분석하였다. Independent t-test, Fisher’s exact test과 linear correlation를 사용하였으며, 치아들은 치아별 (대구치, 소구치, 견치 그리고 전치부), 악궁별(상악, 하악) 그리고 전체 치아로 분류하여 통계학적 분석을 시행하였다.

실험 결과: 운동 전공 학생들은 비운동 전공 학생들에 비해 상악 소구치와 전치부, 하악 대구치, 소구치와 전치부에서 통계적으로 유의하게 높은 수치의 Hooper’s new tooth wear index를 보였다. 운동 전공 학생들은 하악에서 통계적으로 유의하게

높은 수치의 Hooper’s new tooth wear index를 보였다. 운동 전공 학생들은 비운동 전공 학생들에 비해 상악 대구치, 하악 대구치, 소구치와 견치에서 통계적으로 유의하게 높은 양의 교모를 보였다. 운동 전공 학생들은 상악, 하악 그리고 상하악 총합에 대해 비운동 전공 학생들에 비해 통계적으로 유의하게 높은 양의 교모를 보였다. 설문지를 통해 운동 선수들이 비운동 전공 학생들에 비해 나이가 어리고, 몸무게는 무거우며 교모에 대한 자각 정도가 유의적으로 높은 것으로 조사되었다.

결론: 이 논문의 한계 내에서 다음과 같은 결론을 지을 수 있다.

1. 신체적 접촉이 많은 운동은 교모의 정도와 양에 영향을 미친다.
2. Hooper’s new tooth wear index를 사용하여 교모를 분석하였을 때, 운동 전공 학생들은 비운동 전공 학생들에 비해 유의하게 높은 교모 정도를 나타낸다.
3. 교모의 면적을 계측하여 교모를 분석하였을 때, 운동 전공 학생들은 비운동 전공 학생들에 비해 유의하게 높은 교모 양을 나타낸다.

핵심 되는 말: 운동, 교모, 가상 모형, 정도, 양