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Collum angle of maxillary central incisors in patients of different types of malocclusion

Running title: Collum Angle of Maxillary Central Incisors

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Abstract

Background/Purpose:

The Collum angle (the supplementary angle of the crown-root angle) of the maxillary central incisors is extremely important for patients who are undergoing orthodontics and abutment implant. However, there is no report on the Collum angle on the Taiwanese people. Therefore, the purpose of this study was to evaluate the Collum angle of maxillary central incisors in patients with different types of malocclusion.

Materials and methods: This study collected 124 samples of lateral cephalometric radiographs (38 radiographs were from male patients and 86 were from female patients. The age of sampled patients ranged from 8 to 58; the average age was 19.9.). The samples were divided into four groups according to malocclusion type, and the Collum angle of maxillary central incisors in each group was measured. A one-way ANOVA and the Scheffe test were used to compare whether or not the angle was different among the groups.

Results: The average value of the Collum angle was 6.1 ± 5.2° for Class I malocclusion; 5.3 ± 4.2° for Class II Division I malocclusion; 10.6 ± 4.4° for Class II Division 2 malocclusion; and 5.6 ± 5.1° for Class III malocclusion. Statistical analysis showed that the Collum angle of maxillary central incisors for patients with Class II Division 2 malocclusion significantly exceeded the Collum angle values in the other three groups.

Conclusion: Compared with the groups with other malocclusion types, the Collum angle of natural teeth for patients with Class II Division 2 malocclusion was the greatest.

***Keywords*:** cephalometry, maxillary central incisors, crown-root angle, Collum angle; malocclusion.

Introduction

In recent years, dental implant surgery has been widely applied as a method for treating missing teeth. Normally, the survival rate of dental fixtures in the maxillary anterior zone is quite high [1]. However, in the maxillary anterior zone, special malocclusion conditions in patients may cause the angle between the fixture implanted into the maxillary alveolar bone and the externally connecting abutment to be too great, necessitating the use of angled abutment [2,3]. Previous studies have indicated that when using angled abutment in the anterior zone, stress concentrates on the turning point between the buccal side of the fixture and the abutment, causing the gum at this point (the turning point) to experience post-surgery tension, thereby creating the possibility of gingival recession [4-7]. Gingival recession may lead to cosmetic defects. Additionally, if soft tissue transplantation is used in an attempt to repair exposed fixtures, the persistence of tension will cause repaired gums to recede again. Studies have indicated that the extent of recession is related to the bending angle [4-6]. Otherwise, using angled abutment may also cause non-axial occlusal force, leading to sequelae of easy occurrence of **abutment screw** fracture, **abutment screw loosening** or reduction of osseointegration effects [8]. Therefore, understanding the crown-root angle (the angle formed by the intersection of the long axes of the crown and root) in patients with different types of malocclusion is a critical issue.

Among the methods of investigating the **crown-root** angle, also known as the Collum angle (the supplementary angle of the crown-root angle), using lateral cephalometric radiographs is the most common method [9-14]. Although computed tomography (CT) [15] or Cone Beam CT [16,17] can supply 3D spatial structure information, using cephalometric radiographs is adequate for providing sufficient information about central incisors. Additionally, in dental clinics, CT and CBCT are not as easy to obtain as cephalometric radiographs, reducing their applicability.

Previous studies have already indicated that the **Collum angle** differs among groups with different types of malocclusion [9-11,13,14]. However, previous research has largely investigated the crown-root angle or Collum angle from the perception of orthodontic treatment, mainly because dental implant surgery was not common in previous times (twenty to thirty years ago). Up to the present, no related research reports (research on the crown-root angle or Collum angle) regarding Taiwanese patient groups have existed. The aim of this study was therefore to determine the Collum angle of maxillary central incisors in different malocclusion Taiwanese patients by using cephalometric radiographs.

Materials and Methods

Subject collections

The subjects of this study were patients in the Department of Orthodontics at the Dental Department of the China Medical University Hospital. The research studied radiographs from 124 patients, with 38 male patients and 86 female patients. The ages ranged from 8 to 58 years, and the average age was 19.9 years. The orthodontists categorized the patients into four groups according to malocclusion types using Angle Classification by model analysis: Class I malocclusion, Class II Division I malocclusion, Class II Division II malocclusion, and Class III malocclusion. Moreover, in order to clearly measure the Collum angle of maxillary central incisors in the lateral cephalometric radiographs of all the patients, researchers had to be able to identify the natural tooth axis of maxillary central incisors; therefore, no prostheses (post, dental implants, and fixed partial dentures) could be present in the anterior zone. Additionally, lateral cephalometric radiographs showing severe crowding or mixed dentition in the anterior zone were not included.

Collum angle measurements

After sketching the maxillary central incisor type from the lateral cephalometric radiographs, the single observer in this study (Dr. Y-H Wang, the third author of this study) joined the superius point of the incisal edge and the middle point of the cementoenamel junction to depict the crown axis, and then joined the middle point of the cementoenamel junction with the root apex to depict the longitudinal axis. The Collum angle could then be measured, as shown in Figure 1.

The accuracies of the measurements were validated before analyzing the Collum angle of maxillary central incisors.Two statistical analyses were used to assess the reliabilities of intraexaminer and interexaminer measurements. The interexaminer error was determined by **the Collum angle of maxillary central incisors being measured once by** each of two examiners—the **intraclass correlation coefficient (ICC)** and *p* value of repeated-measures **analysis of variance** (ANOVA) were **0.951 and** 0.832**, respectively.** The intraexaminer error was determined by **the**

Collum angle of maxillary central incisors in a certain lateral cephalometric radiograph being measured five times by a single examiner—the **ICC and** *p* value of repeated-measures ANOVA tests were **0.983 and** 0.996**, respectively**. These values indicate that the intraexaminer and interexaminer errors of this method could be neglected in this study.

Statistical analysis

The SPSS 13.0 for Windows (SPSS, Inc; Chicago, Illinois) was used for statistical analysis. The values of the malocclusion types measured from the four groups were input into the software, and the critical point was established at $\alpha = 0.05$. The function operations of the Scheffe test were conducted to examine whether or not any statistically significant differences existed among the four groups.

Results

The Class I malocclusion group had 33 samples; the Class II Division 1 malocclusion group had 32 samples; the Class II Division 2 malocclusion group had 28 samples; and the Class III malocclusion group had 31 samples. The distribution is shown in Table 1. The multiple comparisons of the samples among the four groups shows that the mean of the Class II Division 2 malocclusion group significantly exceeded that of the other three groups (Table 2).

Discussion

Currently, dental implants are a commonly used method for treating missing teeth. In the maxillary anterior zone, the phenomenon of bending to various extents exists between the crown axis and root axis. The probability of applying angled abutment in the maxillary anterior zon is, quite high. Although previous research has investigated the Collum angle (or crown-root angle) [9,10,13,14], such studies have focused on the domain of orthodontic treatment, and, more importantly, have not studied Taiwanese patients. Under a classification model of the four malocclusion types, this study measured the Collum angle of maxillary central incisors in Taiwanese patients.

When substances with properties of radiation and higher impermeability (for example, post or fixed partial dentures) are located near the site to be observed, the influence of such substances may result in artifacts [18] or distortion [19,20]. Additionally, if teeth alignment show severe crowding or higher alveolar bone density, or if mixed dentition causes overly complicated image overlay in the alveolar bone, these phenomena will all cause difficulty in distinguishing maxillary central incisor types. Radiographs that showed fixed partial denture prostheses on the maxillary central incisors were not included in the sample selection range of this study, as natural tooth axes in such cases may have already been altered. Therefore, during sample collection, care must be taken to exclude lateral cephalometric radiographs, such as those described above that negatively influence degree of identification, to reduce error in measurement.

Numerous reasons explain the formation of the Collum angle. Backlund indicated that research relating to tooth morphology and overbite has proposed that the reason may be that the force of the lower lip influences the growth of the maxillary central incisors, causing the phenomenon of bending [21], leading to formation of the Collum angle. Other scholars have indicated that heredity is also a primary cause of maxillary central incisor bending [22].

The age range of the 124 subjects was from **8** to 58 years, with some of the young patients being of mixed dentition. However, the maxillary anterior zone of all the patients, where the research focused on, was in the permanent dentition. Therefore, the research results were not influenced by age differences.

The results of this study showed that the Collum angle of the Class II Division 2 malocclusion group was significantly different from the other three malocclusion group types. These results show a trend (Table 1) similar to those of scholars such as Delivanis [10], Bryant[9], and Williams [14]. Compared to research references, the results of this study showed greater Collum angle values (Table 1). This study inferred that this may be due to the influence of differences in hereditary genes between Western and Oriental races. Bone development in Oriental races tends towards bimaxillary protrusion; therefore, Oriental races have greater tooth axis bending compensate for bony protrusion.

The results of this study imply that if dental implants are used in patients with Class II Division 2 malocclusion, the probability of using angled abutment is also greater. However, using angled abutment causes stress to concentrate on the cortical bone zone contralateral to the abutment turning point [4-6]. In other words, if angled abutment is used in the maxillary anterior zone, stress will concentrate on the facial profile cortical bone zone; that is, the alveolar ridge under the free gingival margin. When stress is concentrated on the alveolar ridge of the facial profile in the maxillary anterior zone, the free gingiva in this zone endures considerable tension. If undue external force (such as damage caused by excessive force during gingival retraction) or eccentric occlusal overload is imposed in addition to this tension, gingival recession may occur and have cosmetic effects.

Additionally, the alveolar ridge of the facial profile in the maxillary anterior zone is usually thinner, and when implant-supported prostheses begin to endure occlusal force, phenomena of micro-vertical bone loss is highly likely to occur. According to the theory of biological width constant, healthy gums also recede along with absorption of the alveolar ridge, causing uneven edges for the free gingiva in the anterior cosmetic region and discordant cervicoincisal length of teeth.

Lapatki researched differences in the level of the lip line and resting lip pressure between patients with Class II Division 2 malocclusion and Class I malocclusion [23]. Results showed that patients with Class II Division 2 malocclusion had a higher lip line, and their resting lip pressure had a positive value on the side margin of the maxillary central incisors but a negative value in the cervical tooth zone. Patients with Class I malocclusion showed opposite phenomena regarding lip line and resting lip pressure. Therefore, Lapatki proposed that the level of lip line and lip pressure are external causal factors of bending between crown and root long axes in maxillary anterior teeth.

This study has several limitations. The first is that because the main purpose of this study was to measure the Collum angle, researchers did not measure the incisor shape. Secondly, although 124 samples of patient data were gathered in total, after categorization into four malocclusion type groups, the number of samples in the Class II Division 2 malocclusion group was less than 30. In the future, sample size could be increased to conduct a more complete analysis.

Conclusion

Regarding the Collum angle between the crown axis and root axis in maxillary central incisors, among patients with different types of malocclusion, the Class II Division 2 malocclusion group showed a significantly greater Collum angle.

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TABLE LEGENDS

Table 1. Reference Collum angles (or crown-root angle) in different malocclusion types (expressed in degree).

Table 2. Multiple comparisons.

FIGURE LEGENDS

Figure 1. Schematic representation of the measurement of the Collum angle.

Table 1. Reference Collum angles (or crown-root angle) in different malocclusion types (expressed in degree).

Malocclusion type	This study						Delivanis [10]	Bryant [b9]	Williams [14]
	Sample number	Mean±SD	95% confidence Interval		Minimum	Maximum	Mean±SD	Mean±SD[b]	Mean±SD
			Lower bound	Upper Bound					
Class I	33	6.1±5.2	4.2	7.9	0.0	19.0	1.5±4.4 [a]	177.5±4.5[b]	-0.7±4.9
Class II-1	32	5.3±4.2	3.8	6.8	-1.5	13.5		179.4±4.0[b]	-1.7±6.3
Class II-2	28	10.6±4.4	8.9	12.3	3	18.0	6.1±5.9	175.2±5.1[b]	1.2±5.9
Class III	31	5.6±5.1	3.7	7.4	2.5	16.0	1.5±4.4[a]	178.6±4.7[b]	0.0±5.3

Note: a: Class I, Class II-1, and Class III in the same pool. ; b: in crown-root angle

Table 2. Multiple comparisons.

Malocclusion type		Mean Difference	Standard Deviation	Significant	95% Confidence Interval	
					Lower Bound	Upper Bound
Class I	Class II-1	0.78	1.18	0.932	-2.56	4.12
	Class II-2	-4.55*	1.22	0.004	-8.00	-1.09
	Class III	0.51	1.19	0.980	-2.86	3.87
Class II-1	Class I	-0.78	1.18	0.932	-4.12	2.56
	Class II-2	-5.33*	1.23	0.001	-8.81	-1.85
	Class III	-2.74	1.20	0.997	-3.66	3.12
Class II-2	Class I	4.55*	1.22	0.004	1.09	8.00
	Class II-1	5.32*	1.23	0.001	1.85	8.81
	Class III	5.05*	1.24	0.001	1.55	8.56
Class III	Class I	-5.06	1.19	0.980	-3.87	2.86
	Class II-1	0.27	1.20	0.997	-3.12	3.66
	Class II-2	-5.05*	1.24	0.001	-8.56	-1.55

Note: * . The mean difference is significant at the 0.05 level.

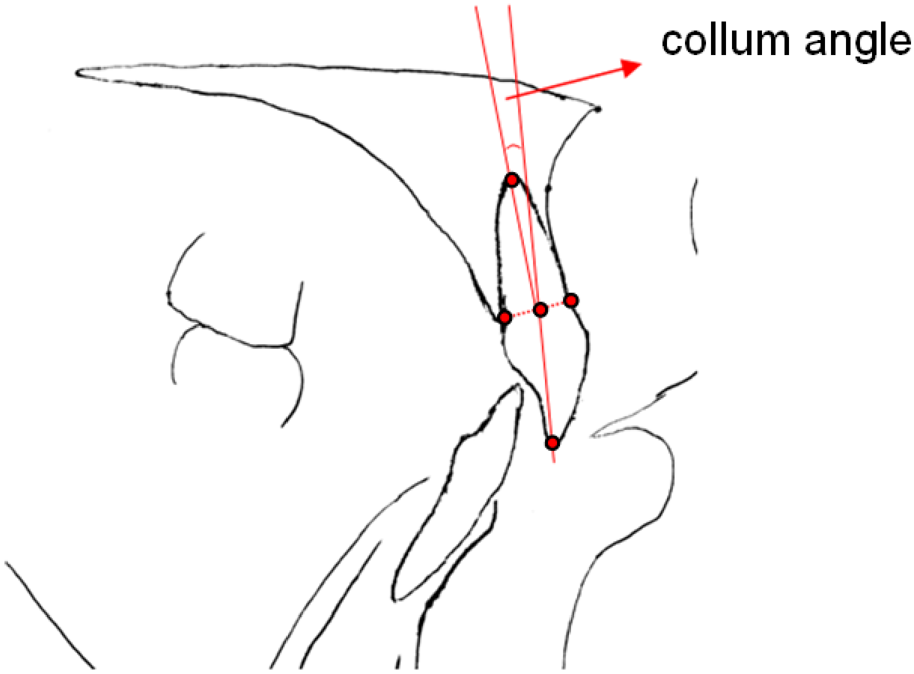

Figure 1. Schematic representation of the measurement of the Collum angle.