Clinical investigation of ideal incisor proportion for anterior tooth alignment in mongolian female adults

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Summary

The goal of dental esthetic treatment is to restore mastication and esthetics. Dental esthetic treatment differs from prosthodontic treatment due to the fact that the former considers the relationship between the anterior teeth and the entire facial configuration, especially around the mouth, to provide a beautiful smile. Rufenacht, in his textbook "Fundamental of Esthetics" in 1990, advocated 10 factors to create a beautiful smile. One of the factors states that "The shape of the anterior teeth has to be in Golden Proportion". Although the factors make sense, the factor regarding the golden proportion raises a question. Hence, we measured the width of the maxillary anterior teeth and compared them to the 'golden proportion'. A total of 162 Japanese female, with an average age of 31 years old were examined. They were treated by orthodontists who are board–certified by the Japanese Orthodontic Association. The subjects underwent orthodontic treatment with an initial diagnosis of Angle class 1, ANB2 to 4 malocclusions with no skeletal involvement. Photographs of the maxillary anterior after orthodontic treatment were used for measurements. Three dentists with more than 5 years of clinical experience measured the width of the maxillary anterior from the photos enlarged by 3.8 times. The crown width obtained from the two–dimensional photographs was 32.48 ± 1.01 mm for central incisors, 23.83 ± 0.89 mm for lateral incisors, and 19.90 ± 1.04 mm for cuspids. The average width of central incisor was 1.36 and the

cuspid was 0.84 with the lateral incisor as 1. It is common that the width of the tooth increases from lateral incisor followed by the cuspid, and the central incisor. However, the harmony of anterior teeth should not be based on the actual width of each tooth, but on the two–dimensional tooth proportion viewed from the anterior, which can be affected by the shape of the dental arch, the angle of each tooth, and so on. According to our results, the ratio of the central to the lateral incisor did not coincide with the golden ratio of 1:1.618 but rather to the silver ratio of 1: $\sqrt{2}$ (1.414), a traditional beautiful proportion in Japanese culture. To compare of results, we used the textbook "Anteriores", by Dr. Jan Hajto and examined the two–dimensional measurement of the maxillary anterior teeth in 32 European female. We concluded that the ideal incisor proportion before and after orthodontic treatment in Asian women is closer to the silver ratio. Even for European female, the ideal incisor proportion is not necessarily the golden ratio, contrary to popular belief.

Introduction

Cosmetic Dentistry is a discipline which deals with esthetics as well as functions of teeth, jaw, oral cavity and face[1]. The goal of Cosmetic Dentistry is to improve the overall appearance of the mouth, constructing a beautiful smile for the patient and harmonizing facial features, in particular, the lips with the anterior teeth. This is very important to consider when carrying out a treatment plan.

Rufenacht advocated 10 concepts in creating a beautiful smile in his book 'Fundamentals of Esthetics' published in 1990[2]. All concepts are reasonable except for one stating that the proportion of the anterior teeth should aim at the golden proportion or the golden ratio. Generally, the golden ratio in terms of the proportion of the maxillary anterior teeth is ideal for Europeans and Americans[3,4]. The golden ratio is considered to be the most harmonious and beautiful from the era of ancient Greece. From the largest to the smallest part with '1' as the middle value, an approximate value of 1.618 is considered as an esthetic indicator of the width of the anterior teeth[3–6]. Specifically, when the maxillary lateral incisor is set to 1.0, the desirable ratio of the central incisor is 1.618 and the cuspid ratio is 0.618[4]. However, there are various opinions on whether the golden ratio can really be used as an esthetic objective index in maxillary anterior teeth[7,8].

The so–called silver ratio or silver proportion (1: $\sqrt{2}$) is considered to be the most beautiful proportion from ancient times in Japan. It is also known as the Yamato ratio. This ratio has been applied to Japanese buildings such as the five–story pagoda of Horyuji Temple as well as the A4 and B5 sizes used in university notes and report paper[9,10]. According to this ratio, when the lateral incisor is set to 1, the width of the central incisor becomes 1.414 and the cuspid becomes 0.707. The proportion of the anterior teeth in two–dimensional standard photograph changes depending on the angulation of the anterior teeth and the shape of the dental arch[11].

In this study, we measured the width of the anterior teeth in each patient after orthodontic treatment in reference to the golden and silver ratio. Comparison of the frequency distribution of the crown width in Japanese and Westerners were analyzed to determine the ideal incisor proportion. Our findings are different from the established 'golden ratio', generally regarded as the ideal proportion.

Materials and Methods

We selected 162 Japanese female patients ranging from 18 to 49 years old (with an average age of 31 years old), diagnosed as skeletal type 1, Angle 1 malocclusion and normal occlusion was established after orthodontic treatment. It was assumed that there was no skeletal vertical deviation or lateral deviation in each patient and prosthetic treatment was not done on anterior teeth.

Standard photography of the frontal view of the maxillary anterior teeth after orthodontic treatment was completed. For photography, Contraster (YDM, Tokyo), mouth hook (YDM), a single–lens reflex digital camera for dental intraoral photography (Canon EOS X7i, Tokyo) and lens (Canon Lens, TECHNO DCC–GP/DUW, Tokyo) were used. A contrast was placed at the back of the maxillary dentition. A black background was placed at the back of the anterior teeth to create a clear photograph of the maxillary incisors (Fig. 1). A square mouth hook that matches the size of the oral cavity was used for the intra–oral standard photography, carefully avoiding force or tension when pulling the lips. The lips were retracted as much as possible to avoid narrowing of the photo range.

The two–dimensional standard photograph was expanded to a lateral width of 18 cm to accurately measure the proximal centrifugal width of the crown. On the enlarged two–dimensional standard photograph, a perpendicular line was drawn from each tooth contact point on both sides of each tooth to the occlusal plane. An electronic digital caliper (NSX MAX–CAL, Japan Micrometer Mfg. Co., Ltd, Hyogo) was used to measure the centrifugal crown width from mesial to the distal contact area and the value was rounded up to the second decimal place. The occlusal plane is the
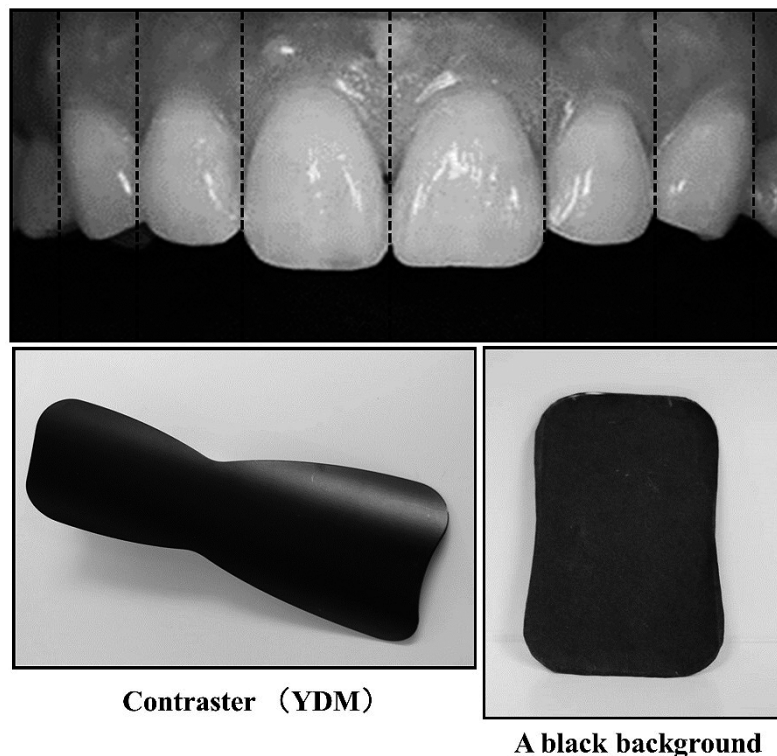

Contraster （YDM）

A black background

Fig. 1：Two-dimensional standard photography of the proximal centrifugal width, measurement method

Table 1 : The width of the maxillary central incisors and lateral incisors from
Japanese and Westerners of two-dimensional standard photography ratio (%)

the ratio of central incisor to the lateral incisor (%)		
Central/Lateral	Japanese	Westerners
1.16 ～ 1.26	14.3	0
～ 1.36	36.6	3.1
～ 1.46	38.5	25.0
～ 1.56	8.7	40.6
～ 1.66	1.9	21.9
～ 1.76	0	9.4

Table 2 : The width of the maxillary lateral incisors and cuspids from Japanese and
Westerners of two-dimensional standard photography ratio (%)

the ratio of the lateral incisors to the cuspids (%)		
Central/Latera	Japanese	Westerners
0.57 ～ 0.66	0.6	6.3
～ 0.76	19.3	34.4
～ 0.86	47.2	37.5
～ 0.96	24.8	18.8
0.96 ～ 1.06	8.1	3.1

level from the mandibular incisor to the farthest molars and the buccal cusp tip on both sides.

Measurements were carried out three times by dentists having 5 or more clinical experience and the mean value was calculated. The ratio was calculated by assigning a value of 1 to the lateral incisor. Using the maxillary dentition model acquired on the same day and the two–dimensional standard photograph enlarged to a width of 18 cm, the ratio of the central incisor on the enlarged two–dimensional standard photograph to the actual measurement was calculated. The ratio of the central incisor was measured in photographs enlarged by 3.8 times in 10 randomly selected cases.

Using the same method, 32 Western female described in Jan Hajto's book[11] was used as the control group. The width of the maxillary central incisors, lateral incisors and cuspids were measured from the photographs. The presence of prosthetic treatment such as restoration of the dental crown on the anterior teeth is known but the age at the time of data collection, the presence or absence of orthodontic treatment, and the actual measurement value of the crown width were unknown.

The width of the maxillary anterior obtained from two–dimensional standard photographs[9,10] was used to investigate the frequency distribution using the golden and silver ratio as the basis of the esthetic index. The crown width of the maxillary anterior teeth in Japanese and Westerners were determined and a frequency distribution table was prepared. Six groups were created for the ratio of central incisor to the lateral incisor ranging from 1.16 to 1.76 (Table 1) and five groups were created for the ratio of the lateral incisors to the cuspids ranging from 0.57 to 1.06 (Table 2). The frequency distribution table of the ratio of central incisor and cuspid to the golden ratio (1.61) and silver ratio (1.41) were compared and the width of the groups was set to 0.1. The anatomical dental crown width (real value) of the six maxillary anterior teeth was measured using electronic digital calipers on cast model obtained at the end of orthodontic treatment.

The study was approved by the Matsumoto Dental College Dental School Ethics Committee (Approval number: 0239).

Results

The width of the maxillary anterior teeth on both sides was measured from the two–dimensional standard photograph of each patient after orthodontic treatment. The average values were 32.48 ± 1.01 mm for the central incisor, 23.83 ± 0.89 mm for the lateral incisor and 19.90 ± 1.04 mm for the cuspid. In the control group, the average ratio of the maxillary anterior teeth in the Westerners is 1.51 for the central incisor, 1 for the lateral incisor and 0.79 for the cuspid.

In the frequency distribution ratio of the maxillary central and lateral incisors in Japanese, the group that coincided with the golden ratio was has a relative frequency of 1.9% and the group that coincided with the silver ratio (1.46) has a relative frequency 38.5% which is higher. When the values obtained from Japanese and Westerners were calculated, the relative frequency of the group that coincided with the golden ratio of 1.62 is 21.9% and the relative frequency of the group that coincided with the silver ratio of 1.41 is 25.0%. The group ranging from 1.47 to 1.56 obtained the highest frequency of 40.6% (Table 1, Fig. 2)

Similarly, the frequency distribution ratio of the cuspid to the lateral incisor in both Japanese and Westerners that coincided with the golden ratio of 0.62 is low with only 0.6% and 6.3% respectively. However, the frequency distribution ratio that coincides with the silver ratio of 0.71 is higher in both Japanese and Westerners with 19.3% and 34.4% respectively. The group ranging from 0.77 to 0.86 obtained the highest frequency of 47.2% for the Japanese and almost 37.5% for the Westerners (Table 2, Fig. 2).
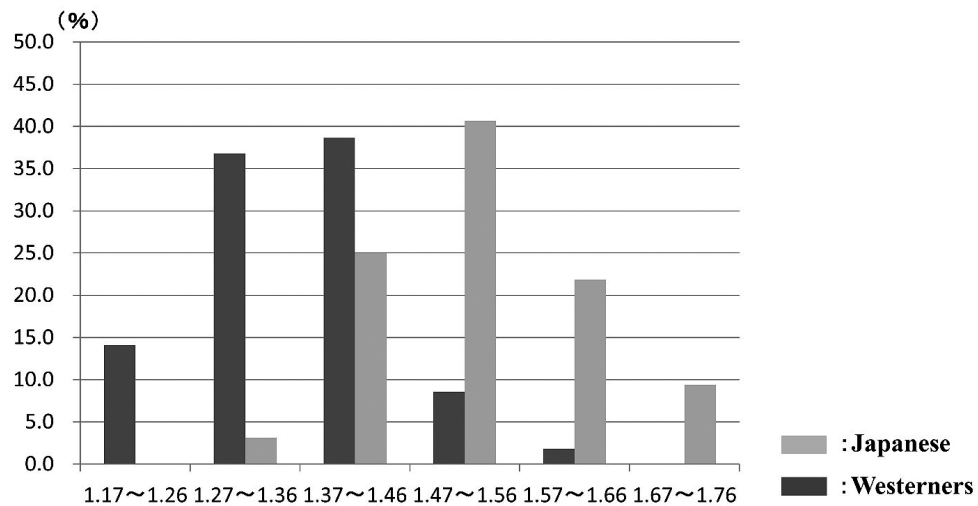

Fig. 2 : The width of the maxillary central incisors and lateral incisors from Japanese and Westerners of two-dimensional standard photography ratio (%)

Table 3 : The anatomical crown width of the maxillary anterior teeth (mm) (Japanese, Westerners[12,15,16,17])

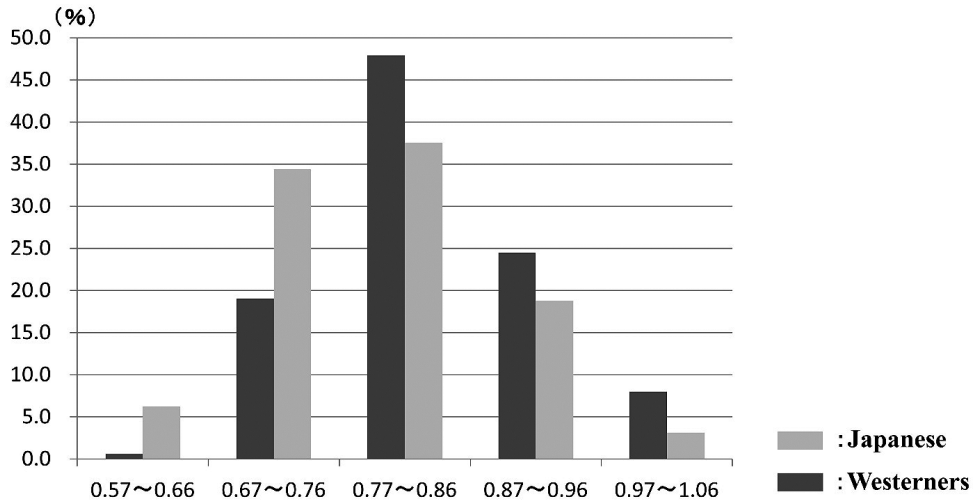| The anatomical crown width of the maxillary anterior teeth (mm)						
Female	Japanese					Westerners	
	Yagasaki	Otsubo	Ono	Hanihara	Fernandes	Hanihara	Fernades
Central	8.40	8.24	8.53	8.50	8.36	8.41	8.40
Laateral	6.84	6.64	7.09	7.00	6.74	6.51	6.51
Cuspids	7.64	7.65	7.81	7.84	7.70	7.57	7.54

Fig. 3 : The width of the maxillary lateral incisors and cuspids from Japanese and Westerners of two-dimensional standard photography ratio (%)
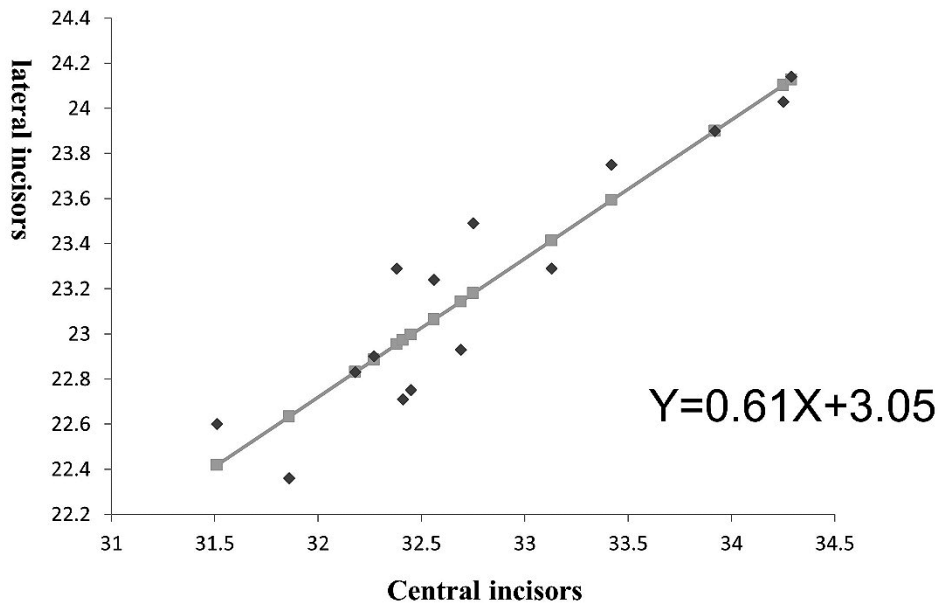

$$Y=0.61X+3.05$$

Fig. 4 : Regression function and scatter plot of the silver ratio

Also, the anatomical crown width from the cast model of the maxillary anterior teeth in 15 persons in the group was measured using electronic digital calipers. The values obtained were 8.40 ± 0.28 mm for central incisor, 6.84 ± 0.26 mm for lateral incisor and 7.64 ± 0.35 mm for cuspid (Table 3, Fig. 3). The maxillary central incisor and lateral incisor has a correlation coefficient of r = 0.93 and regression line Y = 0.61X + 3.05 (Fig. 4).

Discussion

In this study, when the width of the maxillary lateral incisor was set to 1, a width of 1.36 for the central incisor and 0.84 for the cuspid was obtained. Shimada et al[13] photographed the model dentition of a normal occlusion using dental cone beam CT and calculated the ratio of the anterior clinical crown width. From the central incisor to the cuspid, a ratio of 1.38 : 1 : 0.89 on the right side
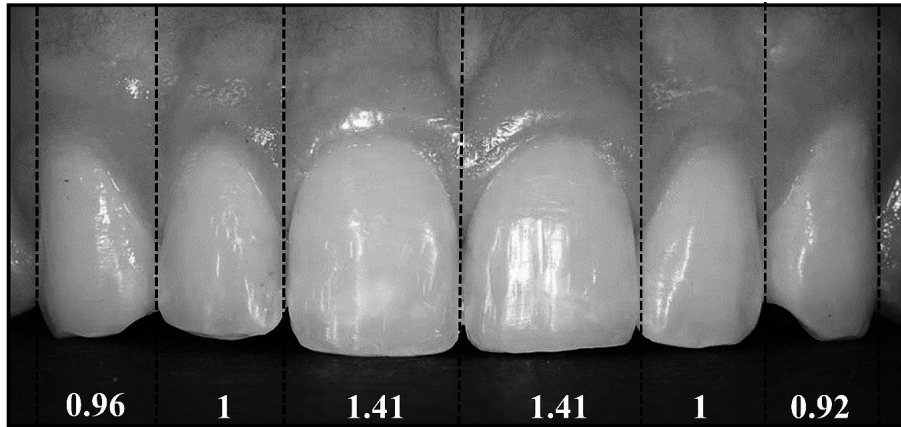
Fig. 5：Similar to the ratio of the proportion of the incisors of Japanese to the silver ratio
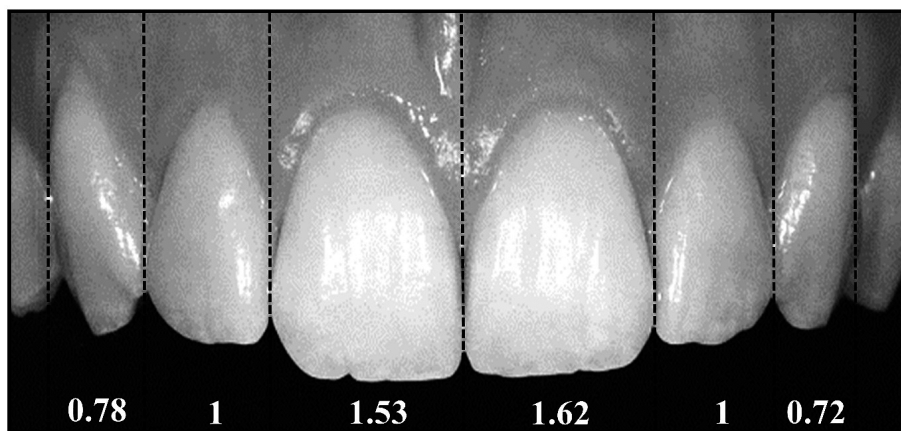

Fig. 6：Similar to the ratio of the proportion of the incisors of Westerners to the golden ratio

and 1.46 : 1 : 0 : 0.87 on the left side were obtained. They stated that the ratio of the maxillary anterior teeth is close to the silver ratio of 1.41. This study is similar to the current study using Japanese women having normal occlusion as subjects, however, the method of measurement is different and the presence or absence of orthodontic treatment was not mentioned.

In the present study, the group ranging from 1.37 to 1.46 which includes the silver ratio (1.41) has the highest percentage of 38.5% while the group ranging from 1.57 to 1.66 which includes the golden ratio (1.62) is only 1.9% (Table 1, Fig. 3). These results are similar to the ratio of the clinical crown width described by Shimada et al in the proportion of the incisors of Japanese to the silver ratio suggesting that it could be considered as the esthetic objective index (Fig. 5).

On the other hand, the ratio of the maxillary central and lateral incisors in Westerners from the two–dimensional standard photograph in the group ranging from 1.57 to 1.66 which includes the golden ratio of 1.618 is 21.9% which is much higher than the Japanese. However, the group in between the golden and silver ratio ranging from 1.47 to 1.56 obtained the highest frequency of 40.6% (Table 1, Fig. 2). Furthermore, the ratio of the lateral incisor to the cuspid in Westerners ranging from 0.57 to 0.66 which includes the golden ratio of 1.62 is low at 6.3% and is barely recognized in Japanese which is only 0.6%.

The ratio of the maxillary lateral incisor to the cuspid ranging from 0.77 – 0.86, which is higher than the silver ratio resulted to a percentage of 47.2% in Japanese and 37.5% in Westerners (Table

2). However, factors such as the form of the cuspid itself, influence of angulation, torque, the morphology of the dental arch were not considered as determining indices. In the study of Preston[14], only 17% of the lateral and central incisors coincided with the golden ratio of 1 : 1.618. The also mentioned that they could not find a correlation between the ratio of the lateral incisor and cuspid to 1 : 1.618.

Next, we measured the anatomical crown width of the maxillary anterior teeth and the values were 8.40 ± 0.28 mm for the maxillary central incisor, 6.84 ± 0.26 mm for the lateral incisor and 7.64 ± 0.35 mm for the cuspid in which the lateral incisor has the smallest width followed by the cuspid and then the central incisor. This is consistent with the results of Otsubo and Ono et al[12,15]. Our results showed that upon examining the ratio of the central incisor to the cuspid where lateral incisor is 1, we came up to a ratio of 1.23 : 1.0 : 1.12 from central, lateral and cuspid. Similarly, previous studies showed the following ratio of the anterior teeth in Japanese as follows – 1 : 1.24 : 1.0 : 1.15 by Ono, et al[16] ; 1.21 : 1.0 : 1.12 by Hanihara, et al[15] and 1.24 : 1.0 : 1.14 by Fernandes, et al[17]. The width of the central incisor ranges from 1.20 to 1.24 and the cuspid ranges from 1.12 to 1.14. When the anatomical crown width of the Westerners and the Americans were measured by Hanihara[15] and Fernandes[17], they came up with 1.29 for the central incisor and 1.16 for the cuspid. Although the results were slightly higher than the Japanese, no significant difference was recognized[15–18].

Based on the results, we determined that the maxillofacial morphology and dental arch form are the reasons for the lack of significant difference in the proportion of the maxillary anterior teeth in Japanese and Westerners despite the difference obtained from the measured values in two–dimensional standard photographs. The Japanese are of Mongoloid origin having a U–shaped dental arch, short head, wide cranial width and a shallow depth while the Westerns are of Caucasoid origin having a V–shaped dental arch, long head with narrow cranial width and a deep base[19].

A beautiful smile is an esthetic indicator of the proportion of the maxillary anterior teeth. A beautiful smile is generally thought to be based on the ideal proportion of the maxillary anterior teeth following the golden ratio. However, in Japanese, our results suggest that the golden ratio is not always the indicator of a beautiful smile. Further evaluation of the form of the dental arch should be considered when determining the esthetic indicators in Japanese and Westerners after normal occlusion has been acquired.

Conclusion

The ratio obtained from measuring the width of the maxillary anterior teeth with normal occlusion after orthodontic treatment in Japanese was close to the silver ratio. The ideal proportion of the maxillary anterior teeth seems to depend on the shape of the cranium. The golden ratio may apply to the Caucasians but the silver ratio is suggested to be the esthetic indicator among the Japanese.

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抄録：日本成人女性における前歯部配列の理想的な切歯のプロポーションに関する検討

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　前歯のプロポーションについて矯正治療後の患者において，黄金比と白銀比を参考に，日本人成人女性の口腔内規格写真上で上顎側切歯の歯冠幅径に対する上顎中切歯と上顎犬歯の歯冠幅径計測し比率の度数分布を比較し，理想的な前歯のプロポーションを検討し，次の結果を得た．

　日本人の矯正歯科治療にて個性正常咬合を獲得した上顎前歯部配列において切歯（中切歯，側切歯）のプロポーションは白銀比に近い値が得られた．上顎前歯部のプロポーションにおいて実測値で大きな差異を認めなかったにも関わらず二次元規格写真から得られた日本人と欧米人のプロポーションの結果が異なった理由として，顎顔面形態，歯列弓形態の違いなどの要因が考えられた．顎顔面形態，歯列弓形態を考慮した場合，多くのモンゴロイド系である日本人は，頭蓋の横幅が大きく奥行きが小さい短頭系でU字型の歯列弓を有するのに対し，コーカソイド系の欧米人は，頭蓋の横幅が小さく奥行きが大きい長頭系で，V字型の歯列弓を有する．

　これにより美しいスマイルは，日本人の場合，上顎中切歯，側切歯のプロポーションは白銀比が審美的指標となり，また，一般的に上顎前歯部のプロポーションにおいて理想といわれている黄金比は，必ずしも美しいスマイルを有する指標とならないことが示唆された．