Original Article

The relationship between malocclusion and menarcheal age, and its secular trend for Korean women

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Objective: This study aimed to evaluate the mean age of menarche, its secular trend in Korean women, and the relationship between malocclusion and the rate of skeletal maturation, as defined by menarcheal age. **Methods:** We retrospectively collected data on menarcheal age from 931 Korean women born during 1961 - 1997. Subjects were divided by the malocclusion type and birth-year decade into 3 and 4 groups, respectively. The mean menarcheal age for each group was determined, and one-way ANOVA was performed for intergroup comparison ($p = 0.05$). Two-way ANOVA was also performed to compare all the 12 subgroups ($p = 0.05$). **Results:** The mean age of menarche was 12.82 years for Korean women born during 1961 - 1997. A distinct downward secular trend of menarcheal age was noticed ($p < 0.05$). For the birth-year decade 1961 - 1970, the Class III malocclusion group showed earlier onset of menarche than the other malocclusion groups ($p < 0.05$), but the other birth-year groups did not show any significant difference in the type of malocclusion ($p > 0.05$). **Conclusions:** A positive secular trend towards earlier menarche exists among Korean women. Malocclusion does not show any significant relationship with the rate of skeletal maturation, as defined by menarcheal age.
[**Korean J Orthod 2012;42(1):11-16**]

Key words: Menarche, Skeletal maturation, Malocclusion, Secular trend

INTRODUCTION

The prediction of pubertal growth spurts enables the determination of both the optimal timing for treatment and prognosis, especially in dentofacial skeletal disorders. Several methods have been proposed for the prediction of pubertal growth spurts.[1,2] However, the considerable individual variation in pubertal growth spurts necessitates the establishment of a reliable indicator that is strongly associated with developmental age.

The following indicators have been used to evaluate developmental age: skeletal maturity index (SMI) from a hand–wrist X-ray film, height velocity curve, dental age, and sexual maturity index from secondary sex characters, such as voice changes, in boys and menarcheal age in girls.

Menarche occurs, on average, 17 ± 2.5 months after the maximum growth in height[2] and at the SMI of 7 or 8.[3] According to Simmons and Greulich,[4] skeletal age is correlated to a greater extent with menarcheal age than with either standing height or annual increments of standing height. With regard to data acquisition, menarcheal age is a simple and reliable parameter to evaluate and predict individual growth because the data are easily collected verbally, without the need for radiography or serial height measurements. Therefore, information on consistent indicators, such as menarcheal age, is thought to be essential for both growth prediction and control of remaining growth during orthopedic treatment. However, since menarche occurs after the growth peak in height, an individual's growth peak cannot be predicted using menarcheal age.

The rate of skeletal maturation may differ according to the type of malocclusion. This study was aimed at evaluating the relationship between skeletal maturation and malocclusion. If a relationship can be defined, it can be used to predict the timing of skeletal maturation and the extent of growth remaining in the jaw. Johnston et al.[5] reported that maturational retardation was partially responsible for Class II malocclusion, but they inves-

tigated Class II subjects only. Kim et al.[6] also found that skeletal maturation in patients with Class II malocclusion began later than in those with Class I or III malocclusion. However, their study population was small, and they did not consider subjects born during the 1990s.

To assess the relationship between the rate of skeletal maturation and malocclusion, the definition of an indicator of skeletal maturation is essential. Although the hand–wrist X-ray film serves as the best indicator of skeletal maturation, serial radiography is necessary to assess the maturation rate. Age at menarche is highly correlated with skeletal maturation; additionally, it is a reliable parameter that is easily ascertained. Therefore, the relationship between malocclusion and skeletal maturation can be retrospectively investigated by comparing the menarcheal age, which is an indicator of skeletal maturation, among different malocclusion groups. However, the clinical application of this indicator to a given population would warrant the reassessment of pubertal stages in the population because secular trends in sexual maturation, including menarcheal age, have been observed in many countries.[7,8]

Therefore, the aims of this study were to evaluate the mean menarcheal age and its secular trend in Korean women. We also sought to evaluate the relationship between skeletal maturation, as assessed by menarcheal age, and malocclusion, which was defined by means of the ANB angle-a parameter well-known as a useful guide to the diagnosis and treatment of malocclusion.[9]

MATERIALS AND METHODS

We retrospectively selected 1,079 Korean women who had visited the Department of Orthodontics, Gangnam Severance Dental Hospital located in Seoul, Korea, for orthodontic treatment. These women met the following criteria: born during 1961 - 1997; living in or around Seoul, Korea; and had obtained a pretreatment lateral cephalogram. Among these patients, 931 women who had specified the month and year of the onset of menarche

Table 1. Mean and standard deviation of ANB angle and comparisons between the malocclusion groups in the 4 birth-year decades

(Unit: degree)

	1961 - 1970	1971 - 1980	1981 - 1990	1991 - 1997	Sig	Total
Class I	2.71 ± 0.98 (n = 63)	2.56 ± 0.93 (n = 100)	2.63 ± 0.85 (n = 100)	2.69 ± 0.88 (n = 76)	NS	2.62 ± 0.89 (n = 339)
Class II	6.68 ± 1.86 (n = 57)	6.61 ± 1.75 (n = 100)	6.04 ± 1.07 (n = 100)	6.09 ± 1.02 (n = 49)	NS	6.30 ± 1.43 (n = 306)
Class III	-2.51 ± 1.51 (n = 31)	−2.37 ± 2.08 (n = 100)	−1.49 ± 1.11 (n = 100)	−1.87 ± 1.79 (n = 55)	NS	−1.98 ± 1.74 (n = 286)

Sig, Significance; NS, not significant.

at the time of initial examination for diagnosis were chosen. The research was approved by the Institutional Review Board of Gangnam Severance Hospital, Yonsei University (No.3-2010-0085). Patients who had a history of orthodontic treatment or orthognathic surgery were excluded since their original sagittal jaw relationship might have been changed by the treatment.

The enrolled subjects were grouped according to the decade of birth and sagittal jaw relationships, which were classified as skeletal malocclusion of Classes I, II, and III by the ANB angle, as per Korean norms.[10,11] Patients with ANB angles of 1° and 4°, more than 5°, and less than 0°, as assessed using the lateral cephalogram (Vceph ver 3.5; Osstem Implants, Seoul, Korea) were divided into 3 groups of skeletal malocclusion Classes I, II, and III, respectively. Borderline cases of ANB angles between 0° and 1° and between 4° and 5° were excluded from the study (Table 1). The mean values for Wits analysis were also calculated for each malocclusion group.

Statistical analysis

The limited number of subjects in each subgroup necessitated the assessment of normality for data distribution. Therefore, Shapiro-Wilk's test (SPSS ver. 12.0; SPSS Inc., Chicago, IL, USA) was used, which revealed normal distribution of the data in all the subgroups.

The mean value and standard deviation of menarcheal age were determined for each subgroup. One-way ANOVA and the least significant difference (LSD) *post-hoc* test were used to compare the 3 malocclusion groups ($p = 0.05$). The same tests were performed to assess the secular trend of menarcheal age among the 4 groups divided by birth-year decade ($p = 0.05$). The 12 subgroups were compared by two-way ANOVA and LSD *post-hoc* test to evaluate the interaction between the type of malocclusion and birth-year decade ($p = 0.05$). One-way ANOVA was performed to compare the malocclusion groups in terms of the mean ANB angles for each birth-year decade.

RESULTS

The mean age (± standard deviation) at menarche was 12.82 (± 0.53) years for Korean women born between 1961 and 1997. Tables 2 and 3 show the mean age at menarche for each malocclusion and birth-year group, respectively. The Class III malocclusion group showed an earlier onset of menarche than the Class I and II malocclusion groups ($p < 0.05$; Table 2). However, the tendency of earlier onset of menarche in the Class III malocclusion group was observed only in the 1961 - 1970 decade (Table 4). In the other birth-year decades,

Table 2. Mean and standard deviation of menarcheal age according to type of malocclusion

(Unit: years)

Malocclusion group	Class I	Class II	Class III	Sig
	12.85 ± 1.15[a]	12.87 ± 1.15[a]	12.65 ± 1.13[b]	*

Sig, Significance. *$p < 0.05$. Analysis by one-way ANOVA and the least significant difference *post-hoc* test ($p = 0.05$). Groups with different letters have a statistically significant difference.

Table 3. Mean and standard deviation of menarcheal age according to birth-year groups

(Unit: years)

Year of birth	1961 - 1970	1971 - 1980	1981 - 1990	1991 - 1997	Sig
	13.52 ± 1.04[a]	13.10 ± 1.11[b]	12.46 ± 1.00[c]	12.24 ± 1.03[d]	*

Sig, Significance; *$p < 0.05$. Analysis by one-way ANOVA and the least significant difference *post-hoc* test ($p = 0.05$). Groups with different letters have a statistically significant difference.

Table 4. Mean and standard deviation of menarcheal age for each subgroup

(Unit: years)

Year of birth	Class I	Class II	Class III	Sig
1961 - 1970	13.67 ± 0.97[a]	13.58 ± 1.10[a]	13.13 ± 1.02[b]	*
1971 - 1980	13.12 ± 1.07[b]	13.19 ± 1.05[b]	13.00 ± 1.21[b]	NS
1981 - 1990	12.55 ± 0.93[c]	12.44 ± 1.04[c,d]	12.39 ± 1.04[c,d]	NS
1991 - 1997	12.21 ± 1.16[d]	12.29 ± 0.95[c,d]	12.23 ± 0.93[c,d]	NS

Sig, Significance; *$p < 0.05$. Analysis by two-way ANOVA and the least significant difference *post-hoc* test ($p = 0.05$). Groups with different letters have a statistically significant difference.
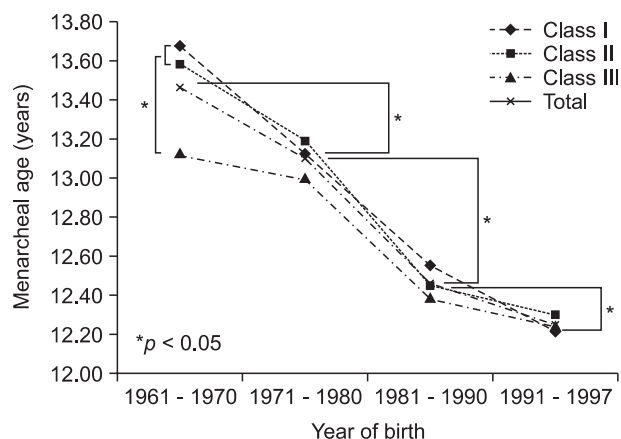
Figure 1. Mean menarcheal age of each malocclusion group.

the 3 malocclusion groups did not show any significant difference in menarcheal age ($p > 0.05$).

The birth-year groups revealed a statistically significant decrease in the age at menarche with each decade ($p < 0.05$), as shown in Table 3 and Figure 1. The menarcheal age of subjects born during the 1960s and 1990s was found to have decreased over time, at 13.52 and 12.24 years, respectively, and a secular trend towards earlier menarche was noticed. Two-way ANOVA showed no statistically significant difference between the malocclusion groups except the 1960s ($p > 0.05$), while a statistically significant difference was observed between the birth-year groups ($p < 0.05$).

No significant differences were noted among the birth-year groups in terms of the type of malocclusion ($p > 0.05$). The mean values of ANB angles were 2.62°, 6.30°, and −1.98° for the Class I, II, and III malocclusion groups, respectively, while those for Wits analysis were −1.82 mm, 1.96 mm, and −8.46 mm, respectively.

DISCUSSION

Various studies on the relationship between menarcheal age and skeletal pubertal growth have indicated that menarche did not occur before maximum skeletal pubertal growth,[2,4,10-12] but 1.1 years after the attainment of peak height velocity.[12] Height increase after menarche is reported to be 6 cm on average.[13] Therefore, menarcheal age can be used as an indicator of the amount of remaining growth as well as skeletal maturation.

Previous studies have shown that patients with Class II malocclusion tend to exhibit slower skeletal maturation than those with other types of malocclusions.[5,6,14] In this study, the Class III malocclusion group showed an earlier onset of menarche than the Class I and II malocclusion groups, while the onset of menarche in the Class I and II malocclusion groups was similar (Table 2). These findings differed from those of two-way

ANOVA, which did not reveal any significant difference between the 3 malocclusion groups ($p > 0.05$) other than that between the Class III malocclusion group and the other malocclusion groups for the birth-year decade 1961 - 1970 (Table 4). Further, a significant difference in menarcheal age was noted among all the birth-year groups ($p < 0.05$); this implied the existence of a distinct downward secular trend of menarcheal age (Table 3). From these findings, we can infer that the onset of menarche was indeed influenced by the birth-year decade but not by malocclusion. One-way ANOVA excluding the data of subjects born during 1961 - 1970 did not show any statistically significant difference among the 3 malocclusion groups. This may indicate that the Class III malocclusion group may have had a tendency of earlier onset of menarche in the past, but over the years, this difference in menarcheal age may have reduced to almost none.

The differences in the average menarcheal age among malocclusion groups for the same birth-year decade decreased with age, which suggests a downward secular trend in menarcheal age. Menarcheal age has decreased worldwide[15] and has been correlated to better nutrition, improvements in both social and economic living conditions, physical developmental status, and increased access to health services.[15-19] The age at menarche decreased in Europe from 17 to 13 in the years between 1830 and 1960.[17] In the United States, it declined from 12.75 to 12.54 years between 1963 - 1970 and 1988 - 1994.[20] In Brazil, the mean age at menarche decreased from 13.07 to 12.40 between the 1920s and the 1970s.[19]

A Korean study on 1,061 subjects born between 1920 and 1986 revealed that the mean menarcheal age decreased from 16.8 to 12.7 years over the 67-year period, which corresponds to a drop of 0.64 years per decade.[21] The study also showed a downward secular trend in menarcheal age although the magnitude of the reduction in menarcheal age per decade tended to decrease. The biggest reduction in age at menarche was evident around 1980, which may be partly due to the rapid socioeconomic development in Korea since the 1980s. The per capita gross national income (GNI) in Korea increased dramatically in the 1980s: the GNI was $401, $1,800, $7,105, and $10,159 in 1973, 1981, 1991, and 2001, respectively.[22] Certain environmental variables, such as improvement in the socioeconomic status and increased access to health service, may have resulted in better nutritional status of Korean women, thereby causing a consistent, earlier onset of menarche and disappearance of the differences between the malocclusion groups. This presumption is supported by the change in the mean height of Korean women; the mean height at the age of 14 years was increased from 152 cm to 158 cm between 1985 and 2006.[8]

Reports indicate that the mean age at menarche in Korea

is approaching that in many countries where the age of onset at menarche is low and has stabilized over the past century.[15] Many European countries have reported a halt in the downward secular trend of menarcheal age.[23,24] However, further long-term studies are needed to confirm the leveling-off of the age at menarche in Korea.

Since retrospective studies based on recall methods are limited by the questionable accuracy of recall, we sought to overcome this problem by discarding the data from subjects who could not remember the events accurately. However, as mentioned by Hwang et al.,[21] menarche may be an unforgettable event for women belonging to a conservative society, such as that in Korea. In addition, our study was based on the mean age at menarche, and not the individual age at menarche. Therefore, the effect of any potential recall error is likely to be small, even if the individual variation is large.

The age at menarche can also be influenced by other environmental factors, such as the educational level of parents, socioeconomic status, and area of residence. Additionally, subjects who had sought orthodontic treatment may not represent the general Korean female population. Nevertheless, most subjects in this study had been born and raised at different regions in Korea and had reached menarche in diverse socioeconomic backgrounds, except those of the 1991 - 1997 birth-year group who reached menarche during orthodontic treatment and had resided around the same area. Therefore, our study sample can be regarded as a representative of the general population of Korean women.

This study aimed to investigate the relationship between skeletal maturation rate and malocclusion. Age at menarche, which was considered the indicator of skeletal maturation in this study, did not differ significantly between the Class I, II, and III malocclusion groups. However, since menarche is a one-shot event, it may not fully represent skeletal maturation. Therefore, studies also considering serial hand–wrist and lateral cephalometric X-ray films may enable a clearer elucidation of the skeletal maturation rate in subjects with different types of malocclusions.

CONCLUSION

There is a positive secular trend towards earlier menarche among Korean women. Our results suggest that there is no significant relationship between malocclusion and the rate of skeletal maturation, as assessed by menarcheal age.

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