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A Study of the Morphological Characteristics of the Dental Arch of Young People in Southern Gansu

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ABSTRACT

We characterized the dental arch morphologies of young people in Southern Gansu using dental model measurements and analyses. Convenience sampling was used to select young people who had not undergone orthodontic or restorative treatment as the study population, including both male (n=21) and female (n=22) participants. The crown width of the teeth, arch width, length, angle, Spee's curvature, available arch space, and required space were measured. The data for each item were statistically analyzed and grouped by sex. The arch widths and lengths were compared between the groups and with individuals in the rest of the country. Arch length and width were greater in men than in women, with statistically significant results for UW4, UW5, UW7, UW4', UW6', LW1, LW3, LW7, LL5, LL6, and LL6' ($p<0.05$). The results of the arch angle measurements (unit: °) were as follows: male and female, maxillary and mandibular cusp angles (128.38 ± 10.71), (129.39 ± 8.58), (137.77 ± 8.41), and (134.88 ± 8.04); male and female, upper and lower first premolar angles (109.70 ± 9.98), (109.68 ± 7.71), (115.38 ± 8.52), and (116.68 ± 6.94); and male and female, upper and lower first molar angles (89.60 ± 8.70), (90.53 ± 7.19), (92.25 ± 8.27), and (93.32 ± 7.33). The available arch space was greater for females than males, whereas the required space was greater for males ($p<0.05$). The crown widths of the teeth were in descending order. There was a significant sex difference in the crown width of teeth 13, 33, and 42 ($p<0.05$). Spee's curvature mean values were 3.15 ± 0.69 mm and 2.59 ± 0.61 mm for male and female participants, respectively, with a significant difference between the groups ($p=0.007$). The difference between the vertical distance between the maxillary lateral incisors, the mandibular first premolar, mandibular second molar, and the middle palatal suture was statistically significant ($p<0.001$). Asymmetry in U2 and L7 being more prominent in females than males. Clinical considerations should be given to regional and sex differences to better perform various treatment tasks, such as restoration of the dental arch shape.

Keywords: Southern Gansu; Arch morphology; Sex differences; Oral health; Young population

INTRODUCTION

The dental arch is located at the most anterior part of the jawbone; it carries teeth and is an important component of the masticatory system. The morphological characteristics of the dental arch, including indicators of arch size, arch space, arch angle, and Spee's curvature, are closely linked to numerous

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dental tasks. For example, in orthodontic treatment, long-term stability of the arch morphology is one of the main problems faced by orthodontists, and arch morphology is the best reference before the patient is treated [1,2]. Dong Chunmei reported that, in esthetic restorations, the arch length can be increased by altering the teeth, thus improving lip fullness [2]. The measurement of the arch length can provide a basis for digital and individualized aesthetic analysis. A national sample survey on the status of missing teeth and denture restoration among Chinese adults conducted by Guo Jing and other scholars in 2018 stated that successful impression taking is a prerequisite for conventional restorations, while arch size and circumference are important references for tray selection [3]. This indicates that a study of arch morphology is important for clinical work in dentistry.

The complexity of dental arch morphology, which varies from person to person, has made it the subject of several morphological studies [4,5]. Arch width, length, tooth position morphology, genetics, environment, and sex all have a significant impact on an individual's arch morphology [6]. As a result, dental arch morphology varies significantly between regions and populations. However, the lack of research on dental arch morphology in different regional populations has caused problems in local dental clinical practice.

Therefore, in this study, we measured the crown width, arch size, angle, length, symmetry, Spee's curvature, available arch space, and required space in young people in southern Gansu to demonstrate and analyze their dental arch morphology, with the aim of providing a reference for dental treatment planning and research in the local population.

MATERIAL AND METHODS

Experimental Materials and Instruments

The following materials were used: dental alginate impression material (Tianjin Densberg Jelrate Company; China); large, medium, and small disposable plastic dental trays (Wuhan Golden Light Company; China); super-hard plaster (S-M-L SUPT); a rubber bowl (Wuhan Golden Light Company; China); a blending knife (Wuhan Golden Light Company; China); a disposable oral instrument case (Guangdong FLPC Company; China); disposable rubber gloves (Mi Sieve Wave; Shanghai, China); a vibrating machine (Wuhan Golden Light Company; China); electronic digital vernier calipers (Harbin Gauge Group Inc.; China); a subgauge (Wuxi Drafting Instruments Company; China); and angle rulers (Wuxi Drafting Instruments Company; China).

Participants and Study Methods

Study participants: A total of 43 students (aged 20.47 ± 1.74 years), including 21 male (20.31 ± 1.85 years) and 22 female participants (20.27 ± 1.65 years), from both the Gannan and Linxia regions of Gansu were enrolled from Northwest Minzu University in October 2021 using a convenience sampling method. There was no significant difference between male and female sample ages t=0.075, p=0.941. The inclusion criteria were as follows [7]: maxillary and mandibular sides with complete permanent incisors, canines, premolars, and molars (excluding third molars); no severe tooth detrition on the mesial, distal, and occlusal sides; and complete dentition without restorations, such as vestigial crowns and bridges. The exclusion criteria were as follows: severely vestigial crowns and edentulous, neither parent from southern Gansu (Gannan and Linxia), participant's not born and raised in southern Gansu, and history of prosthodontics and orthodontic treatment. All participants provided written informed consent. This project has been approved by the Ethics Committee of Northwest Minzu University.

Research methods: Models were constructed as follows: First, participants who met the requirements were screened. Next, suitable trays were selected according to the size of the jaws of the study participants. In the third step, impressions were fabricated using the Densberg Jelrate impression material (1:1.2 water to powder ratios). This involved sterilization and infusion of super hard plaster into the model immediately after the acquisition of impressions. Finally, the infused models were saved. The impressions made and the filled plaster models were accurate, clear, and free of air bubbles and included the complete dental row (excluding the third molar), arch, basal bone, migrating folds, palatal vault, and labiobuccal ligament [7]. The 43 plaster casts were evaluated by three experienced physicians using electronic digital vernier calipers with an accuracy of 0.01 mm, parting gauges, and rulers in double blind measurement. Each data point was measured three times, and the average value was calculated.

Statistical Analysis

SPSS software (version 23.0) was used for statistical analysis of the data, and the measurements are presented as the mean ± standard deviation (x ± S). When analyzed by the t-test within groups, differences with p=0.05 were considered statistically significant.

Measurement Items and Methods

1. Crown width was defined as the distance between the proximal and distal mesial contact points of the crown of each tooth to be measured, expressed as W11 to W15, W21, W25, W31 to W35, and W41 to W45.
2. Arch width was defined as the distance between the distal and middle incisal margins of the incisors on both sides, between the cusps of the cuspids, and between the buccal cusps of the molars, denoted as UW1-UW7 and LW1-LW7, where the anterior (between the cuspids), middle (between the central fossa of the first premolar), and posterior (between the central fossa of the first molar) are UW3 (AB), UW4' (CD), UW6' (EF), and LW3, LW4', LW6', respectively.
3. For arch length, the proximal-central contact point of the central incisor was the starting point, and the line between the distal-central contact points of the left and right lateral homonymous teeth (i.e., the arch width) was the baseline. The vertical distance between the starting point and the baseline was measured as the arch length, denoted as UL1-UL7 and LL1-LL7, where the anterior, middle, and posterior segments are UL3 (OG), UL4' (OH), UL6' (OI), LL3, LL4' and LL6', respectively.
4. AS was defined as the length of the overall curved shape of the dental arch. Using a brass wire with a diameter of 0.5

mm, the distance from the point of proximal-mid contact of the first molar along the buccal cusp (surface) of the premolar, cusp of the cusp, and incisive edge of the incisor to the point of proximal-mid contact of the contralateral first molar was calculated. RS was defined as 5-5 the sum of the widths of the crowns of the individual teeth.

5. For the dental arch angle, the angle formed between the cusp of the left and right cusps, the central fossa of the left and right first premolars, and the central fossa of the left and right first molars, respectively, was measured using the proximal-central contact point of the central incisor as the apex. The angle was measured directly on the model using an angle ruler (accuracy of two points; Wuxi Drawing Instrument Company) (AOB: angle of the cuspids, COD: angle of the first premolar, and EOF: angle of the first molar).
6. Arch symmetry was denoted as U1-U7 and L1-L7, where U1 is the difference between 11 and 21, the vertical distance between the distal mesial incisal margin and palatal mesial suture, left minus right, and the rest by analogy.
7. Spee's curvature: A straightedge was placed on the buccal cusp of the incisal end of the lower incisor and lower second molar. The vertical distance between this line and the lowest point of the buccal cusp line of the tooth was measured, and the left and right-side measurements were summed to obtain the average.

RESULTS

The arch length and width measurements and comparisons for young people in southern Gansu.

No significant differences in arch angles (p>0.05) were found among the participants.

Table 1 presents the crown width measurements and comparison between groups of participants.

Table 1: Measurement of crown width and comparison between groups (x Â ± S, mm)

	Male (n=21) x ± s	Female (n=22) x ± s	t-value	p-value
15	6.92 ± 0.41	6.88 ± 0.47	0.296	0.769
14	7.64 ± 0.44	7.39 ± 0.53	1.678	0.101
13	8.19 ± 0.40	7.87 ± 0.59	2.078	0.044*
12	7.02 ± 0.37	7.17 ± 0.94	0.682	0.499
11	8.60 ± 0.35	8.54 ± 0.75	0.333	0.741
21	8.67 ± 0.41	8.52 ± 0.75	0.806	0.425
22	7.19 ± 0.41	7.22 ± 0.93	0.136	0.892
23	8.17 ± 0.48	7.92 ± 0.68	1.389	0.172
24	7.60 ± 0.33	7.43 ± 0.41	0.491	0.144
25	6.84 ± 0.46	7.00 ± 0.53	1.053	0.299
45	11.13 ± 0.80	11.05 ± 0.74	0.34	0.736
44	7.26 ± 0.54	7.22 ± 0.56	0.238	0.813
43	7.44 ± 0.46	7.20 ± 0.50	1.633	0.11
42	7.25 ± 0.51	6.94 ± 0.44	2.138	0.039*
41	6.27 ± 0.39	6.04 ± 0.54	1.597	0.118
31	5.58 ± 0.32	5.41 ± 0.41	1.504	0.14
32	6.15 ± 0.36	6.05 ± 0.46	0.787	0.436
33	7.15 ± 0.41	6.83 ± 0.52	2.238	0.031*
34	7.45 ± 0.58	7.31 ± 0.40	0.927	0.359
35	7.21 ± 0.58	7.06 ± 0.49	0.92	0.363

Note: Comparisons between male and female group t-tests; *p<0.05, **p<0.01, ***p<0.001

The measured values of Spee's curvature for participants from southern Gansu and comparisons between the groups are shown in. Differences between the left and right sides of male participants from southern Gansu ranged from 0.00 to 1.06 mm, while differences in female participants ranged from 0.07 to 1.00 mm (excluding negative values). The difference between the right and left arches was not less than 1.00 mm between L34 and L44 in male participants or between L37 and L47 in female participants, with significant symmetry between the U2, L4, and L7 arches (p<0.05).

It shows an intergroup comparison of the arch size measurements of participants from southern Gansu with those of the rest of the Chinese population.

DISCUSSION

In a multicentre retrospective study conducted in 2000 by the Orthodontic Committee of the Chinese Society of Stomatology, the prevalence of malocclusion in the early stages of permanent dentition was found to reach as high as 72.92% based on the prevalence of individual normal dentition in different age groups in seven regions of China. The Fourth National Oral Health Epidemiological Survey showed that the periodontal health rate among the young population was only 34.8%. Overall, 32.3% of the population had incomplete teeth. These figures reflect the prevalence of oral diseases in the country, as well as the magnitude of the task of clinical work in dentistry. If a patient is missing teeth for too long, the adjacent teeth will tilt and move, and the opposing teeth will elongate, which will inevitably lead to a deformation of the dental arch. In orthodontic treatment, the incidence of ectopic maxillary cuspids in young people is high, and patients with moderate to severe ectopic maxillary cuspids are usually treated by extraction, resulting in incomplete arch morphology. One of the main clinical manifestations in patients with periodontal disease is the loosening and displacement of teeth, which in turn leads to varying degrees of change in the morphology of the dental arch. Due to the variability in awareness of oral visits by periodontal patients, the majority of non-clinical patients with underlying periodontal disease have some degree of altered arch morphology [8]. In this study, we studied the dental arch morphology of young people with no history of orthodontic or restorative treatment in southern Gansu. To a certain extent, this allowed us to understand the oral health of young people in the region.

Prior studies on the measurement of dental models in different regional populations have found that it is important to study arch morphometry in different regional populations. The southern part of Gansu is a remote area with unique food and culture, inhabited by ethnic minorities. Thus far, few measurements have been made of the morphological characteristics of the dental arches of young people in the region. Measurements of the dental arch have gone through different stages. Currently, the three main data sources for digital models are intraoral

scanning techniques, cone-beam computed tomography, and plaster models, each with advantages and disadvantages [9]. Studies have confirmed that there are no statistically significant differences between digital models, digital measurements, and plaster model measurements ($p>0.05$) [10]. The plaster model allows for fixed-point and multiple repetitive measurements, thereby reducing measurement errors to a large extent and ensuring reliable and accurate data. Careful observation of the number, shape, and size of teeth from all directions in the plaster model for abnormalities and misalignments can compensate for the lack of clinical oral examinations. There are significant differences in the anatomy and physiology of male and female individuals due to the phylogeny and social division of labor [11]. Craniofacial structures in the human body are sex-differentiated during development, and include various anatomical structures (e.g., cranial base, bone volume, mouth opening, temporomandibular joint, dental morphology, and teeth) [12]. This, in turn, leads to differences between sexes in terms of disease and dental clinical treatment needs. For example, pain associated with temporomandibular disorders is more common in women, the risk of root resorption is greater in men than in women, and the rate of caries is significantly higher in women than in men [13]. In this study, the data for each item were statistically analysed and presented in groups according to sex where arch width and length were compared between groups with those of individuals in the rest of the country (**Tables 1-3**).

Yu et al. analyzed sex and population differences; using five commonly used crowding prediction methods, they measured and predicted 140 dental models and significantly impacted the predictions' reliability and generalizability. This study showed significant differences between the maxillary available space (UAS), maxillary required space (URS), and mandibular required space (LRS) groups ($p<0.001$), with all UAS being greater in women than in men, and all URS being greater in men than in women ($p<0.001$), indicating maxillary male individuals have more crowded teeth than female individuals. Foletti et al. previously suggested that Spee's curvature could be used as an independent predictor of final facial height and that studies related to malocclusion have contributed to the development of orthodontic clinical diagnosis and treatment [14]. At present, it is believed that the sex difference in Spee's curvature is not statistically significant, while the present study found that the sex difference in Spee's curvature in southern Gansu was significant ($t=2.828$, $p=0.007$) [13]. Whether this is due to the small sample size requires further investigation. The effect of tooth size on arch morphology is direct, with three teeth (13, 33, and 42) showing significant differences ($p<0.05$) in width between the groups. These results suggest that sex-specific treatments should be individualized for dental clinical practice.

In recent years, the introduction of the shortened dental arch treatment concept has provided a new restorative option for posterior edentulism, which changes with age and social circumstances; it may allow patients to meet their functional needs without the need for 28-32 teeth. Some scholars believe that enlarging the lower cuspids as little as possible while changing the arch morphology can achieve more satisfactory long-term results. They pointed out that the average arch width between the mandibular cuspids is 24-26 mm, and that expansion of the arch for treatment should be performed following certain rules. In contrast, the mean values of 37.29 mm and 35.90 mm for male and female mandibular cusps, respectively, were obtained in this study, with no significant differences ($p>0.05$). In addition, the measurements in this study revealed some sex differences in all indicators of dental arch morphometry in southern Gansu. The following finding was particularly noteworthy: the difference between the sexes in UW6', UW7, LW7, and LL6 were highly significant ($p<0.01$). In comparison with measurements in other regions of China, the dental arch width in the young population in Southern Gansu was wider overall, with a shorter anterior and middle arch and an overall wide and short arch pattern. As the arch width of the population in Xi'an was greater for females than for males, except for the population of the Xi'an region, where males predominated. The difference in arch width between the groups was significant ($p<0.05$) in the posterior maxillary segment and almost identical in the posterior mandibular segment in southern Gansu province. There was a significant difference ($p<0.05$) between the groups in the length of the posterior mandibular arch in southern Gansu. Differences between the groups in the depth of the anterior mandibular arch were generally consistent with those in the Xi'an area, all being greater in women than in men.

CONCLUSION

This study only examined sex differences in various measurements of dental arch morphology in the young population of southern Gansu. Whether sex differences in arch morphology are consistent across age groups and whether regularity exists between palatal capping height, tooth size, Bolton index, basal bone, alveolar arch, and dental arch morphology remains unclear. Moreover, the magnitude of the influence of oral hygiene and prevalence, nutritional status, dietary habits, perioral muscle strength, and geographical environment on dental arch morphology also remains uncertain. Hence, arch morphology should be further investigated using a larger sample size. However, despite these limitations, this study should provide a strong basis for future studies.

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DATA AVAILABILITY STATEMENT

Raw data were generated in (our lab). Derived data supporting the findings of this study are available from the corresponding author (ZhouJianye) on request.

CONFLICT OF INTEREST

The author's declared that they have no conflict of interest.

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