Original Article

Radiographic Features Associated with Temporomandibular Joint Disorders among African, White, Chinese, Hispanic, and Indian Racial Groups

S Obamiyi, S Malik[1], Z Wang, S Singh, EP Rossouw[1], L Fishman[1], C Feng[2], D Michelogiannakis[3], RH Tallents

Division of Orofacial Pain and Temporomandibular Joint Disorders, Eastman Institute for Oral Health, University of Rochester, [1]Division of Orthodontics and Dentofacial Orthopedics, Eastman Institute for Oral Health, University of Rochester, [2]Department of Biostatistics and Computational Biology, Eastman Institute for Oral Health, University of Rochester, [3]Department of Community Dentistry and Oral Disease Prevention, Division of Orthodontics and Dentofacial Orthopedics, Eastman Institute for Oral Health, University of Rochester, NY, USA

Abstract

Context: Various radiographic features have been associated with temporomandibular joint disorders (TMDs); however, these characteristics have not been compared among different racial groups. **Aims:** To radiographically evaluate and compare craniofacial patterns and condylar findings suggestive of TMD among African, White, Chinese, Hispanic, and Indian racial groups. **Settings and Design:** This multicenter retrospective study used data from three private orthodontic practices and a University Orthodontic Clinic. **Subjects and Methods:** Panoramic and lateral cephalometric radiographs were collected from 250 subjects who were equally divided into five racial groups: Africans, Whites, Chinese, Hispanics, and Indians. All radiographs were initial records from patients seeking orthodontic treatment. Linear and angular cephalometric measurements were used to evaluate and compare cephalometric characteristics associated with TMD among groups. Panoramic radiographs were analyzed to compare the presence of condylar abnormalities and antegonial notching among groups. **Statistical Analysis Used:** One-way analysis of variance, followed by Tukey's test. **Results:** African and Chinese groups had the smallest mean cranial base measurements, while the Indians had the largest. The mean *Y*-axis value was significantly larger in the Chinese group compared with the other groups. Increased mandibular plane angles were seen in the Chinese and African patients, compared with subjects from other groups. The mean percentage of condylar anomalies was higher in the Chinese subjects compared with all other groups. **Conclusions:** Chinese patients presented with more radiographic features suggestive of TMD, whereas the Indians showed the least, compared with subjects from the White, Black, and Hispanic racial groups.

Keywords: *Craniofacial patterns, ethnicities, races, temporomandibular joint disorders*

Date of Acceptance:
23-Jul-2018

Introduction

The Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) for Clinical and Research Applications, as recommended by the International RDC/TMD Consortium Network and Orofacial Pain Special Interest Group, provided a widely accepted taxonomic classification of temporomandibular disorders which include temporomandibular joint disorders (TMDs), masticatory muscle disorders, and headache attributed to TMD and associated structures.[1] TMDs encompass disc displacement disorders, degenerative joint disease, and subluxation.[1] The DC/TMD further subclassified osteoarthrosis and osteoarthritis under the broader term degenerative joint disease (DJD), a term which

Access this article online	
Quick Response Code:	Website: www.njcponline.com
	DOI: 10.4103/njcp.njcp_63_18

Address for correspondence: Dr. RH Tallents, Division of Orofacial Pain and Temporomandibular Joint Disorders, Eastman Institute for Oral Health, 625 Elmwood Avenue, Rochester, NY 14620, USA. E-mail: ross_tallents@urmc.rochester.edu

How to cite this article: Obamiyi S, Malik S, Wang Z, Singh S, Rossouw EP, Fishman L, *et al*. Radiographic features associated with temporomandibular joint disorders among African, White, Chinese, Hispanic, and Indian racial groups. Niger J Clin Pract 2018;21:1495-500.

is also endorsed by the American Association of Oral and Maxillofacial Surgeons.[2] Moreover, Katzberg *et al*. demonstrated the localized association between disc displacement and DJD of the temporomandibular joint.[3] Several other studies have also suggested that disc displacement without reduction may progress to osteoarthritis of the temporomandibular joint (TMJ).[4-7]

Even though the prevalence of signs and symptoms of TMD increases with age, the reported prevalence of internal derangements is similar in both adults and children. These figures vary widely in the literature, ranging from 4% to 34% in infants, children, and adolescents,[8-13] and 0% to 32% in adults.[14-16] Tallents *et al*. have suggested that this striking observation may indicate the potential for joint remodeling to start at a young age.[17] It is pertinent to mention that most of these epidemiological studies were done in North America and Europe with predominantly White patients. Interestingly, the US Center for Disease Control reports that arthritis affects racial/ethnic populations disproportionately in the United States.[18] It is speculated that a similar trend might be observed regarding TMJ osteoarthritis.

Several authors have indicated that internal derangements of the TMJ can manifest as an altered craniofacial structure.[19-21] Cephalometric variables have shown significant differences in the craniofacial pattern of individuals with TMD including disc displacements and DJD when compared with controls.[22-26] The aim of the present retrospective study was to radiographically evaluate and compare craniofacial patterns and condylar findings suggestive of TMD among African, White, Chinese, Hispanic, and Indian racial groups.

Subjects and Methods

This was a retrospective analysis of panoramic and cephalometric radiographs of patients who were seeking orthodontic treatment. This study was approved by the Office for Human Subject Protection, Research Review Board of University of Rochester, New York, USA. Radiographs were collected from 250 subjects who were equally divided into five racial groups: Africans, Whites, Chinese, Hispanics, and Indians. Specifically, the radiographs for the African, Chinese, and Indian groups were collected from private orthodontic practices in Lagos (Nigeria), Wuhan (China), and Hyderabad (India), respectively, whereas radiographs for the Hispanic and White groups were obtained from the University Orthodontic Clinic at Eastman Institute for Oral Health, University of Rochester, Rochester (USA). Formal written agreements were provided by the private dental providers from Nigeria, China, and India to use their records for the purposes of our study. The records were collected without any identifiers (name, date of birth, chart number, etc.) via encrypted and password-protected thumbdrives. Subjects in the different racial groups were matched by age and gender to ensure comparability.

Inclusion criteria

Initial panoramic and cephalometric radiographs were obtained from subjects aged 12–20 years. All subjects pursued orthodontic treatment in the aforementioned clinical settings between 1/1/2010 and 1/1/2015. The decision to study a pre-orthodontic sample was predicated on the higher prevalence of disc displacement in patients seeking orthodontic treatment (45%),[27] compared with a random sample (30%–34%).[8,16]

Exclusion criteria

Patients with systemic diseases, such as rheumatoid arthritis, lupus, spondyloarthritis, and psoriasis were excluded. Patients with fixed prosthesis (implants or fixed partial dentures or habit breaking appliances) were also excluded from this study.

Null hypothesis

There are no statistically significant differences in the cephalometric characteristics and in the presence of condylar findings suggestive of TMD among the five racial groups.

Cephalometric measurements

Table 1 describes the cephalometric landmarks and reference lines that were used. Angular and linear cephalometric measurements were performed to assess the cranial base length, the anteroposterior jaw relationship and the vertical relationship among the five racial groups [Figure 1].

Panoramic measurements

Panoramic radiographs were analyzed for condylar pathology and antegonial notching [Figure 2].

Statistical methods

One-way analysis of variance (ANOVA) was used to compare the mean values of each measurement among five groups. Tukey's multiple comparison procedure was used for the pairwise comparisons. The significance level was set at 0.05. All statistical analyses were implemented with SAS 9.4 software (SAS Institute Inc., Cary, NC).

Error of measurements

All cephalometric radiographs were traced by a calibrated orthodontist (SM) and then retraced by the same examiner 2 weeks later. The mean of the two values was taken for each of the cephalometric measurements. The panoramic radiographs were evaluated for the presence of condylar pathology and antegonial notching by three postdoctoral fellows in the Orofacial Pain/TMD Program at the University of Rochester (SS, SO, ZW), independently. Any disagreements were resolved via discussion.

Results

Cephalometric analysis

Table 2 summarizes the mean cephalometric values for all five racial groups under three major categories: cranial base measurements, anteroposterior jaw relationship measurements, and vertical relationship measurements. For each variable, one-way ANOVA was used to compare the difference among five groups.

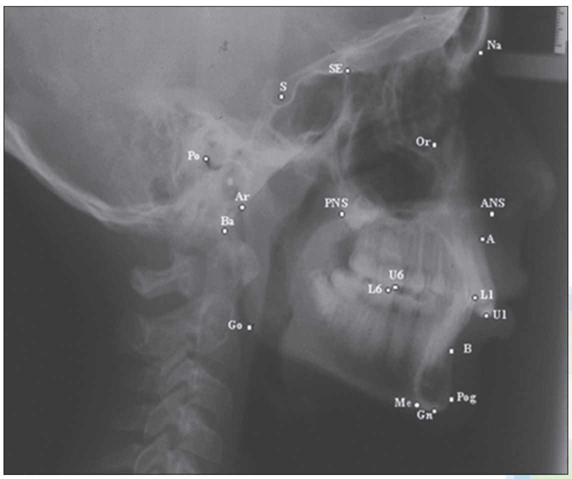

Figure 1: Cephalometric landmarks. Sella turcica (S) N; nasion (Na); basion (Ba); porion (Po); orbitale (Or); articulare (Ar); anterior nasal spine; posterior nasal spine; subnasale (A); lower 1 incisal (L1); upper 1 incisal (U1); supramental (B); pogonion (Pog); menton (Me); gonion (Go); gnathion (Gn)

Tukey's multiple comparison test was used to compare the difference between any two groups.

Cranial base

The mean S-N and S-Ba measurements were found to be smallest in the African group, second smallest in the Chinese group, and largest among the Indian patients. Tukey's pairwise comparison showed significant differences in the mean S-N values between each of the groups, except between Hispanics and Whites, where the difference was not significant. There were also significant differences in the mean S-Ba values between Africans and the other racial groups, with the smallest mean value found in Africans, and the largest in Indians. The mean S-Ba values were significantly different between the Chinese and Indian groups ($P = 0.0001$).

Anteroposterior jaw relationship

There were significant differences in the mean SNA angles between Africans and Whites, Chinese and Indians, and Chinese and Whites. The Chinese group had the largest mean SNA value, whereas Whites had

Figure 2: Panoramic parameters

Table 1: Landmarks and reference lines for the cephalometric measurements

Landmark symbol	Landmark name	Description
Cranial base		
S-N	Sella-Nasion	Anterior cranial base length: The linear distance between sella turcica (S) tableand anterior point of the frontonasal suture (N)
S-Ba	Sella-Basion	Posterior cranial base length: The linear distance between sella turcica (S) and basion (Ba)
Anteroposterior jaw relationship		
S-N-A	Sella-Nasion-A-point angle	Anteroposterior position of the maxillary base (A-point) relative to the anterior cranial base (SN)
S-N-B	Sella-Nasion-B-point angle	Anteroposterior position of the mandibular base (B-point) relative to the anterior cranial base (SN)
A-N-B	A-point-Nasion-B-Point angle	The difference between SNA and SNB angles, representing the anteroposterior relationship of the jaws relative to each other
ANS-PNS	Maxillary length	The linear distance between ANS and PNS
Vertical relationship		
FH to MP	Mandibular plane angle	The angle formed between a plane tangent to the lower border of the body of the mandible (through gnathion) and the Frankfort Horizontal plane
Y-axis	Sella Gnathion to Frankfort Horizontal Plane angle	The angle formed between a plane passing through Sella and Gnathion and the Frankfort Horizontal plane

ANS=Anterior nasal spine; PNS=Posterior nasal spine

Table 2: Cephalometric measurements for each racial group

Cephalometric measurements	Mean±SD				
	Africans	Chinese	Hispanics	Indians	Whites
Cranial base					
S-N	60.38±8.36	66.42±4.01	74.82±4.39	78.70±4.39	74.98±4.96
S-Ba	39.84±5.36	48.52±4.33	50.68±4.50	52.86±4.29	50.22±5.86
Anteroposterior jaw relationship					
S-N-A	85.04±4.80	86.34±7.44	84.20±5.23	82.34±4.59	81.45±5.01
S-N-B	80.88±5.65	85.24±9.98	80.86±5.08	80.12±5.96	78.10±4.64
A-N-B	5.04±2.98	4.06±2.56	3.84±2.51	4.30±2.91	3.78±3.31
ANS-PNS	47.06±6.73	51.39±3.48	58.54±4.28	60.34±4.22	58.81±3.71
Vertical relationship					
FH to MP	27.24±6.68	27.65±5.19	26.18±8.59	20.42±6.04	23.80±7.76
Y-axis	58.22±4.98	62.13±3.64	58.13±4.09	57.00±4.79	58.59±5.64

SD=Standard deviation; ANS=anterior nasal spine; PNS=Posterior nasal spine

Table 3: Antegonial notching and condylar anomalies among groups

Racial groups	Antegonial notching (%)	Condylar anomaly (%)
Africans	60	36.4
Chinese	58	46
Hispanics	60	14
Indians	34	36
Whites	34	34

the lowest compared with the other groups. One-way ANOVA was significant for the mean SNB values, with significant differences found between Chinese and every other group. Similar to the SNA value, the largest mean SNB value was seen in the Chinese group, whereas the lowest was found in White patients. There were no significant differences in the mean ANB values between groups. The mean palatal plane length (ANS-PNS) was highest in Indians and lowest in the African and Chinese groups. Significant differences in the mean palatal length were found between Africans and every other group, as well as between Chinese and every other group.

Vertical relationship

The mean mandibular plane angle (FH to MP) was found to be highest in the African and Chinese groups, whereas it was lowest in the Indian group. There were significant differences in the mean mandibular plane angles between Indians and the other groups (except Whites). Significant differences were reported in the mean *Y*-axis values between the Chinese and every other group, with the Chinese group showing the largest value.

Panoramic radiograph analysis

A summary of an analysis of the panoramic radiographs is presented in Table 3. In the African group, 60% of the patients had antegonial notching on either or both sides of the mandible and 36% of them showed condylar anomalies (flattening, irregularity, osteophytes) in at least one condyle. In the Chinese group, 58% of the subjects had antegonial notching, with 46% of them showing abnormal condyles. Although 60% of Hispanics had antegonial notching, only 14% exhibited condylar anomalies. Regarding the Indian patients, 34% had antegonial notching, whereas 36% of them had abnormalities in at least one condyle. In the White group, 34% of the patients had both antegonial notching and condylar abnormalities.

Discussion

A relationship between disc displacement and facial growth has been suggested by several authors.[5,17,28] Schellas *et al*. proposed that in the growing facial skeleton, internal derangement of the TMJ may retard or arrest condylar growth, ultimately resulting in mandibular deficiency or asymmetry.[28] In addition, Brand *et al*. found significantly shorter maxillary and mandibular lengths in patients with disc displacement when compared with individuals with normal TMJs.[29] Moreover, an association between internal TMJ derangement and craniofacial morphology has been reported; however, a cause and effect relationship could not be established.[30] Although various radiographic features have been associated with TMD, these characteristics have not been evaluated among different racial groups. This multicenter retrospective study evaluated and compared craniofacial patterns and condylar findings suggestive of TMD between African, White, Chinese, Hispanic, and Indian racial groups. It was hypothesized that racial differences might exist in the presence of radiographic characteristics suggestive of TMD among the five groups. The present findings support the latter hypothesis.

Previous studies have demonstrated that cranial base length in patients with TMD is smaller compared with a control group. Both shorter anterior (SN) and total (Ba-Na) cranial base lengths have been reported in TMD patients.[22,24] Moreover, a shorter posterior cranial base length has been reported in patients with TMJ disc displacement.[29] In our study, the African and Chinese groups had the smallest cranial base measurements, whereas the Indians had the largest.

The mandibular denture base has been noted to be retruded in TMD patients, as demonstrated by a smaller SNB angle,[24] and an increased overjet.[22] Furthermore, Stringert and Worms have reported an increased ANB angle in TMD patients,[25] which agrees with the fact that the mandible tends to be more retrognathic in TMD patients compared with controls. In this study, White subjects had the smallest mean SNB value compared with all other racial groups.

Steep mandibular plane angles (MP to FH) have been reported in TMD patients.[22,23] The steepness of this angle results in a hyperdivergent relationship of the maxillo-mandibular skeleton and an increased lower anterior facial height.[17] It has been suggested that this hyperdivergent profile may be a result of the downward and backward rotation of the mandible as the condyle shortens due to arthritic changes.[17] In our study, the African and Chinese groups had the highest mandibular plane angles. In addition, Gidarakou and coinvestigators reported a more vertical *Y*-axis in a TMD sample compared with a control group.[22] In this study, a significantly larger mean *Y*-axis value was found in the Chinese group compared with the other racial groups.

Panoramic radiographs are an important screening tool for observing condylar pathology. Antegonial notching is commonly observed with ipsilateral TMJ derangements and regressive condylar remodeling changes.[28] In our study, the presence of antegonial notching was higher in Africans, Chinese, and Hispanics (approximately 60%) when compared with Whites and Indians (34%). Moreover, condylar changes indicative of pathology on a panoramic radiograph include condyle flattening, osteophyte formation, and/or vertical ramus asymmetry.[5,17,31,32] In this study, condylar anomalies were observed in all racial groups; however, racial differences were identified in the percentage of patients presenting condylar findings [Table 3]. Considering the high prevalence of disc displacement in infants, children, and adolescents (4%-34%),[8-13] and even the higher prevalence in a preorthodontic sample (45%),[27] these percentages are not surprising. Nonetheless, the percentage of subjects with condylar anomalies in the Chinese group (46%) was found to be notably high, which might suggest an increased risk of developing TMD in Chinese patients.

It is pertinent to mention that due to the low reliability of two-dimensional imaging in detecting condylar anomalies, results obtained from panoramic radiographs should be interpreted with caution.[33] Future prospective studies are needed to evaluate condylar anomalies in different races with the use of cone beam computed tomography and/or magnetic resonance imaging to minimize diagnostic errors. Nonetheless, in a clinical setting, such as an orthodontic clinic, panoramic and lateral cephalometric radiographs are routine diagnostic procedures. Therefore, careful evaluation for the presence of radiographic features associated with TMD in these radiographs may reveal the need for further diagnostic testing and assist in early detection of TMD. Furthermore, thorough radiographic assessment in different racial groups may help identify populations with an increased risk of developing TMD and appropriately delegate healthcare funds.

Conclusions

It is concluded that patients from the Chinese group, and to a lesser extent from the African group, presented with more radiographic features suggestive of TMD compared with the other racial groups. Patients from the Indian group showed the least radiographic features associated with TMD among the racial groups included in this study. This conclusion cannot be construed as a direct attribution of risk or predilection of TMD in any specific race. Instead, it highlights the need for future studies to consider racial differences in the study of potential risk factors of TMD.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Schiffman E, Ohrbach R, Truelove E, Look J, Anderson G, Goulet JP, *et al.* Diagnostic criteria for temporomandibular disorders (DC/TMD) for clinical and research applications: Recommendations of the international RDC/TMD consortium network* and orofacial pain special interest group†. J Oral Facial Pain Headache 2014;28:6-27.
2. American Association of Oral and Maxillofacial Surgeons. Parameters of Care: Clinical Practice Guidelines for Oral and Maxillofacial Surgery (AAOMS ParCare 2012). J Oral Maxillofac Surg 2012;70:e204-31.
3. Katzberg RW, Tallents RH, Hayakawa K, Miller TL, Goske MJ, Wood BP, *et al.* Internal derangements of the temporomandibular joint: Findings in the pediatric age group. Radiology 1985;154:125-7.
4. Westesson PL, Rohlin M. Internal derangement related to osteoarthrosis in temporomandibular joint autopsy specimens. Oral Surg Oral Med Oral Pathol 1984;57:17-22.
5. Link JJ, Nickerson JW Jr. Temporomandibular joint internal

derangements in an orthognathic surgery population. Int J Adult Orthodon Orthognath Surg 1992;7:161-9.

6. Eriksson L, Westesson PL. Clinical and radiological study of patients with anterior disc displacement of the temporomandibular joint. Swed Dent J 1983;7:55-64.
7. Yamada K, Hiruma Y, Hanada K, Hayashi T, Koyama J, Ito J, *et al.* Condylar bony change and craniofacial morphology in orthodontic patients with temporomandibular disorders (TMD) symptoms: A pilot study using helical computed tomography and magnetic resonance imaging. Clin Orthod Res 1999;2:133-42.
8. Ribeiro RF, Tallents RH, Katzberg RW, Murphy WC, Moss ME, Magalhaes AC, *et al.* The prevalence of disc displacement in symptomatic and asymptomatic volunteers aged 6 to 25 years. J Orofac Pain 1997;11:37-47.
9. Alamoudi N, Farsi N, Salako NO, Feteih R. Temporomandibular disorders among school children. J Clin Pediatr Dent 1998;22:323-8.
10. List T, Wahlund K, Wenneberg B, Dworkin SF. TMD in children and adolescents: Prevalence of pain, gender differences, and perceived treatment need. J Orofac Pain 1999;13:9-20.
11. Stockstill JW, Bowley JF, Dunning D, Spalding P, Stafford K, Erickson L, *et al.* Prevalence of temporomandibular disorders (TMD) in children based on physical signs. ASDC J Dent Child 1998;65:459-67, 438.
12. Paesani D, Salas E, Martinez A, Isberg A. Prevalence of temporomandibular joint disk displacement in infants and young children. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1999;87:15-9.
13. National Institute of Dental and Craniofacial Research. Facial Pain. Available from: http://www.nidcr.nih.gov/DataStatistics/FindDataByTopic/FacialPain/. [Last accessed on 2015 Aug 20].
14. Kircos LT, Ortendahl DA, Mark AS, Arakawa M. Magnetic resonance imaging of the TMJ disc in asymptomatic volunteers. J Oral Maxillofac Surg 1987;45:852-4.
15. Kaplan PA, Tu HK, Sleder PR, Lydiatt DD, Laney TJ. Inferior joint space arthrography of normal temporomandibular joints: Reassessment of diagnostic criteria. Radiology 1986;159:585-9.
16. Westesson PL, Eriksson L, Kurita K. Reliability of a negative clinical temporomandibular joint examination: Prevalence of disk displacement in asymptomatic temporomandibular joints. Oral Surg Oral Med Oral Pathol 1989;68:551-4.
17. Tallents RH, Stein S, Macher DJ, Katzberg RW, Murphy W. Predisposing and precipitating factors in temporomandibular disorders. Semin Orthod 2012;18:10-29.
18. Bolen J, Schieb L, Hootman JM, Helmick CG, Theis K, Murphy LB, *et al.* Differences in the prevalence and severity of arthritis among racial/ethnic groups in the united states, national health interview survey, 2002, 2003, and 2006. Prev Chronic Dis 2010;7:A64.
19. Schellhas KP. Internal derangement of the temporomandibular joint: Radiologic staging with clinical, surgical, and pathologic correlation. Magn Reson Imaging 1989;7:495-515.
20. Schellhas KP, Piper MA, Omlie MR. Facial skeleton remodeling due to temporomandibular joint degeneration: An imaging study of 100 patients. AJR Am J Roentgenol 1990;155:373-83.
21. Nickerson JW Jr., Møystad A. Observations on individuals with radiographic bilateral condylar remodeling. J Craniomandibular Pract 1982;1:20-37.
22. Gidarakou IK, Tallents RH, Stein S, Kyrkanides S, Moss ME. Comparison of skeletal and dental morphology in asymptomatic volunteers and symptomatic patients with unilateral disk displacement with reduction. Angle Orthod 2004;74:212-9.
23. Nebbe B, Major PW, Prasad NG. Adolescent female craniofacial morphology associated with advanced bilateral TMJ disc displacement. Eur J Orthod 1998;20:701-12.
24. Bósio JA, Burch JG, Tallents RH, Wade DB, Beck FM. Lateral cephalometric analysis of asymptomatic volunteers and symptomatic patients with and without bilateral temporomandibular joint disk displacement. Am J Orthod Dentofacial Orthop 1998;114:248-55.
25. Stringert HG, Worms FW. Variations in skeletal and dental patterns in patients with structural and functional alterations of the temporomandibular joint: A preliminary report. Am J Orthod 1986;89:285-97.
26. Dibbets JM, van der Weele LT. Signs and symptoms of temporomandibular disorder (TMD) and craniofacial form. Am J Orthod Dentofacial Orthop 1996;110:73-8.
27. Kamelchuk L, Nebbe B, Baker C, Major P. Adolescent TMJ tomography and magnetic resonance imaging: A comparative analysis. J Orofac Pain 1997;11:321-7.
28. Schellhas KP, Pollei SR, Wilkes CH. Pediatric internal derangements of the temporomandibular joint: Effect on facial development. Am J Orthod Dentofacial Orthop 1993;104:51-9.
29. Brand JW, Nielson KJ, Tallents RH, Nanda RS, Currier GF, Owen WL, *et al.* Lateral cephalometric analysis of skeletal patterns in patients with and without internal derangement of the temporomandibular joint. Am J Orthod Dentofacial Orthop 1995;107:121-8.
30. Nebbe B, Major PW, Prasad Ng. Female adolescent facial pattern associated with TMJ disk displacement and reduction in disk length: Part I. Am J Orthod Dentofacial Orthop 1999;116:168-76.
31. Papadaki ME, Tayebaty F, Kaban LB, Troulis MJ. Condylar resorption. Oral Maxillofac Surg Clin North Am 2007;19:223-34, vii.
32. Arnett GW, Milam SB, Gottesman L. Progressive mandibular retrusion – Idiopathic condylar resorption. Part I. Am J Orthod Dentofacial Orthop 1996;110:8-15.
33. Ladeira DB, Cruz AD, Almeida SM. Digital panoramic radiography for diagnosis of the temporomandibular joint: CBCT as the gold standard. Braz Oral Res 2015;29:1-7.