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ORIGINAL ARTICLE

Dentofacial characteristics of patients with rheumatoid arthritis

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Abstract
Objectives The aims of this study are to evaluate the dentofacial morphology of patients with rheumatoid arthritis (RA) and to compare the morphological data with those of healthy age- and sex-matched control subjects.
Methods Twenty-seven RA patients (mean age, 45.77± 8.64 years) and 25 healthy subjects (mean age, 44.80± 8.24 years) participated in this prospective study. Clinical and functional evaluations of the RA patients were assessed. The erythrocyte sedimentation rate, C-reactive protein level, rheumatoid factor level, and anti-citrullinated peptide antibodies (ACPA) titers of RA patients were determined, and DAS28 scores were calculated. Linear and angular measurements were performed on cephalometric tracings and condylar erosion was evaluated on lateral panoramic radiographs. Statistical comparison of the two groups was performed with an independent samples *t* test. Pearson correlation analysis was used to assess the relationship between the clinical and laboratory parameters.
Results Based on DAS28 scores, no patient with RA was in the remission period, 3 patients had low, 23 had medium, and 1 had high disease activity. Sixteen (59.26 %) patients with RA had positive ACPA titers. Lateral cephalometric radiographs revealed statistically significant difference between the two groups for the measurement of U1–NA (millimeter; p=0.047), U1–NA (degrees; p=0.031), L1–NB (degrees; p=0.030), IMPA (L1–MP; p=0.001), interincisal angle (U1–L1; degrees; p=0.022) and midface length (Co–A; millimeter; p=0.033). A significant positive linear correlation was found between disease duration time and DAS28 scores (r=0.066, p=0.040).
Conclusions Dentoalveolar effects of RA on dentofacial morphology are more significant than the skeletal effects. Future studies with larger sample sizes are required to evaluate the exact effects of RA on dentofacial morphology.
Clinical relevance Clinicians should consider the fact that RA-associated dentoalveolar changes can be observed and may affect the orthodontic treatment process.

Keywords Rheumatoid arthritis · Dentofacial morphology · Cephalometry

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Introduction

Rheumatoid arthritis (RA) is a chronic inflammatory systemic disease with an unclear etiology that dominantly involves the joints [1, 2]. RA possesses many clinical features of systemic diseases, but abnormalities in the synovial structure and function are the primary manifestations [3]. Symmetrical joint alteration is a characteristic feature of this disease [2]. It is well-known that RA often involves the temporomandibular joint (TMJ), particularly in the severe form of the disease. Reported frequencies of TMJ involvement vary between 2 and 86 % [4–7]. RA also affects the function of the masticatory system [8, 9]. Muscular weakness and atrophy are hallmarks of RA. These muscular abnormalities can be related to pain or inflammatory changes [2, 10].

The most characteristic radiographic signs of RA in the TMJ are reduced joint space and synovial proliferation resulting in disk deformation, fragmentation, and destruction. Severe destruction of the cortical and subcortical bone can ultimately lead to almost complete loss of the condyle [2, 11]. In patients with progressive disease, the joint space becomes obliterated because of loss of condylar height and retrognathia, and an anterior open-bite deformity occurs because of destruction, erosion, sclerosis, and flattening of the articular surface of the condyle and eminence [4, 5, 12, 13].

Juvenile idiopathic arthritis (JIA) is defined as arthritis that starts before the age of 16 years, persists for at least 6 weeks, and has no specific cause [14, 15]. Many previous studies have investigated the dentofacial morphology of patients with JIA [6, 7, 11, 14, 16], but to our knowledge, dentofacial characteristics of adult patients with RA have never been evaluated. The aim of this study was to evaluate the dentofacial characteristics of adult patients with RA and to compare the morphological data with those of healthy age- and sex-matched control subjects. Our null hypothesis was that the dentofacial characteristics of adults with RA do not differ from those of healthy age- and sex-matched control subjects.

Fig. 1 Lateral cephalometric radiograph of a female rheumatoid arthritis patient

Materials and methods

Twenty-seven patients with a previous diagnosis of RA based on the criteria of the American Rheumatism Association (mean age, 45.77±8.64 years) and 25 age- and sex-matched control subjects (mean age, 44.80±8.24 years) were included in the study. This controlled clinical and radiological study was approved by the Ethics Committee of Süleyman Demirel University, Faculty of Medicine, and all subjects provided written informed consent of their participation in the study.

The patients in this study had RA and were referred to the Süleyman Demirel University, Education and Research Hospital, Division of Rheumatology. Healthy subjects who were referred to the Süleyman Demirel University, Faculty of Dentistry, Dentomaxillofacial Radiology Department for diagnostic examination and orthodontic treatment served as controls. The inclusion criteria were as follows: age of >30 years, no previous orthodontic treatment, class I skeletal pattern, not edentulous, and no history of diseases affecting the TMJ and masticatory system. Patients with JIA and two edentulous patients with RA were excluded from the study according to these criteria.

All RA patients were examined by the same rheumatologist (Y.U.). The erythrocyte sedimentation rate (ESR), C-reactive protein (CRP) level, rheumatoid factor (RF) level, and anti-citrullinated peptide antibody (ACPA-titers) of RA patients were determined, and the Disease Activity Score-28 (DAS28) was calculated for each patient.

Lateral cephalometric radiographs (Fig. 1) and lateral panoramic radiographs (Fig. 2) were obtained with a panoramic radiography unit (Planmeca 2002 CC Proline unit: Planmeca Co., Helsinki, Finland). The control group comprised patients who were referred for orthodontic treatment and underwent lateral cephalometric radiographs that were obtained for initial orthodontic diagnosis. All lateral cephalometric radiographs were taken by the same operator with the teeth in maximal intercuspation in a cephalostat with the Frankfort horizontal plane parallel to the floor. Landmarks on lateral cephalometric radiographs were identified with a 0.3-mm pencil following the landmark definitions. Ten linear and ten angular measurements (Fig. 3) were performed from cephalometric tracings by one author (A.Y.G.) to avoid interobserver variability. One subject in the control group and two patients with RA were missing the upper incisors, and one patient with RA was missing a lower incisor. Some measurements could not be performed because of the subjects' missing incisor teeth and these tracing values were excluded from the statistical analysis.

Condylar erosion was evaluated on lateral panoramic radiographs (Fig. 2). Lateral panoramic images were analyzed for condylar erosion and scored from 0 to 4 (0, no erosion; 1, very slight erosion; 2, erosion of the top of the condyle; 3, erosion of half of the condyle; and 4, complete erosion of the condyle). Scores of 0, 1, and 2 were evaluated as slight condylar erosion, while scores of 3 and 4 were evaluated as marked condylar erosion.

The Statistical Package for the Social Sciences (SPSS), version 18.0 for Windows (SPSS Inc., Chicago, IL), was used for data analysis. Descriptive statistics, including the mean and standard deviation, were calculated for all measurements. Statistical comparison of the two groups was performed with an independent samples t test. Statistical significance was pre-determined as $p<0.05$. Pearson correlation analysis was used to assess the relationship between the clinical (disease duration time) and laboratory parameters (DAS28 score).

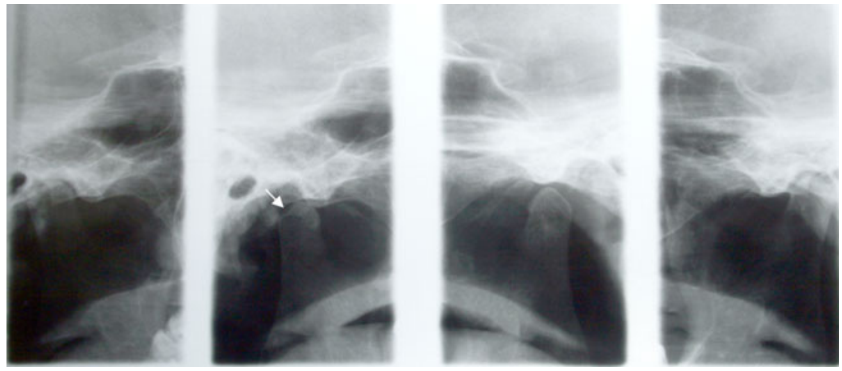

Fig. 2 A cropped lateral panoramic radiograph of a rheumatoid arthritis patient, showing slight condylar erosion (*arrow*) on the right condyle

Results

The characteristics of the subjects are summarized in Table 1. The patients with RA were between the ages of 30 and 61 years (mean age, 45.77±8.64 years), while control subjects were 30–56 years (mean age, 44.80±8.24 years). Disease duration of RA patients ranged between 2 and 20 years (mean 5.52±4.37 years). Seventeen (62.96 %) of the RA patients had positive RF. Fourteen (51.85 %) of the RA patients had a high ESR, and six (22.22 %) had high CRP levels. The RF level was between 10 and 494 IU/ml, ESR level was between 5 and 40 m/h,

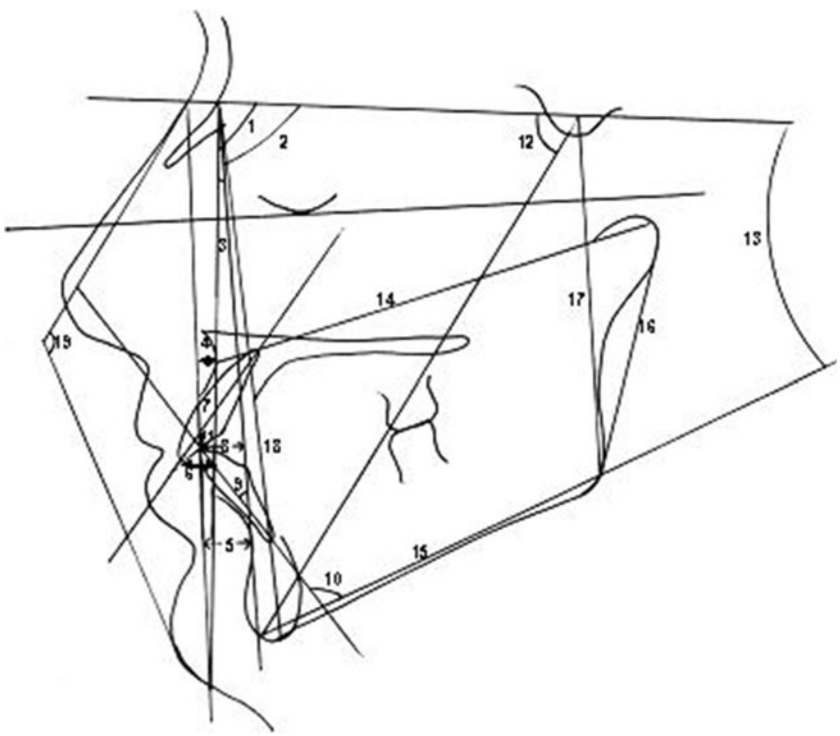

Fig. 3 Landmarks and reference lines used for cephalometric analysis. *1* SNA (degrees), angle formed between sella, nasion, and point A; *2* SNB (degrees), angle formed between sella, nasion, and point B; *3* ANB (degrees), angle formed between SNA and SNB planes; *4* A–Na Perp (millimeter), distance between the point A and nasion perpendicular; *5* Pg–Na Perp (millimeter), distance between pogonion and nasion perpendicular; *6* U1–NA (millimeter); the distance from U1 to the line joining nasion to point A; *7* U1–NA (degrees), angle formed by the intersection of the long axis of the upper central incisor and the line joining nasion to point A; *8* L1–NB (millimeter), the distance from L1 to the line joining nasion to point B; *9*L1–NB (degrees), angle formed by the intersection of the long axis of the lower central incisor and the line joining nasion to point B; *10* IMPA (L1–MP; degrees), angle formed by the intersection of the long axis of the lower central incisor to the line joining gonion to menton.; *11* interincisal angle (degrees), angle formed between the long axis of the upper and lower incisors; *12* SGn–SN (degrees), angle formed by the intersection of SGn and SN; *13* SN–GoGn (degrees), anle formed by the intersection of SN and GoGN; *14* Co–A (millimeter), distance between condylion and point A; *15* Go–Gn (millimeter), distance between gonion and gnathion; *16* Ar–Go (millimeter), ramus height; *17* SGo (millimeter), distance between sella point and gonion; *18* NaMe (millimeter), distance between nasion and menton; *19* Soft Tissue Convexity (degrees)

and the CRP level was between 3 and 70 mg/l. No patients with RA were in the remission period. Based on DAS28 scores, 3 patients had low disease activity, 23 had medium disease activity and 1 had high disease activity. Sixteen (59.26 %) patients with RA had positive ACPA titers.

A Significant positive linear correlation was found between disease duration time and DAS28 scores (r=0.066, p=0.040). Marked condylar erosion was determined only in one female patient, and her disease duration was 15 years. Slight condylar erosion was observed in four RA patients and in only one control subject.

Among the angular and linear measurements statistically significant difference between the two groups were shown in U1–NA (millimeter; p=0.047), U1–NA (degrees; p=0.031), L1–NB (degrees; p=0.030), IMPA (L1–MP; p=0.013), interincisal angle (U1–L1; degrees; p=0.022), and midface length (Co–A; millimeter; p=0.033; Table 2).

Discussion

This study investigated the effects of RA on the dentofacial morphology of adults. Early diagnosis and treatment of RA reduce joint destruction, preserve function, and improve survival in RA patients [17]. It was reported that early referral to a rheumatologist and treatment especially in the first 3 months may be the most important "joint-protecting" measure for patients with RA [18]. The RA patients in our study were treated medically and controlled regularly in the Department of Rheumatology. Marked condylar erosion was determined in only one patient and disease duration was more than 5 years. Disease duration time and DAS28 score showed a significant positive linear correlation in our study. This result indicates that RA patients with a longer disease duration showed higher DAS28 scores. The number of patients with TMJ involvement in the RA group was higher than that in the control group, but the severity of TMJ involvement was thought to be reduced with the effect of regular treatment.

The dentofacial morphology of JIA patients has been well described in several studies. Overall, common findings include small mandibular dimensions, posterior rotation of the mandible in relation to the cranial base or a retrognathic mandible, a steep mandibular plane, short ramus, an obtuse gonial angle, increased antigonial notching, gonial apposition, increased anterior facial convexity, and decreased posterior facial height [16, 19–23]. Larheim et al. [19] investigated JIA patients from 15 to 35 years of age and found symmetrically underdeveloped mandibles and unaffected maxillae. Fjeld et al. [22] investigated the changes in the dentofacial morphology of JIA patients from 6 to 35 years of age and found that in adults, the main differences were a steeper mandibular plane, a smaller and more retrognathic mandible, and more proclined mandibular incisors compared with the healthy controls. To our knowledge, dentofacial characteristics of the adult patients with RA have never been evaluated with the exception of these studies that were performed on JIA patients.

The antero-posterior position of the maxilla and mandible were assessed by SNA and SNB angles as well as maxillary skeletal (A–Na Perp) and mandibular skeletal (Pg–Na Perp) measurements. According to the SNA angle, SNB angle, and mandibular skeletal (Pg–Na Perp) measurements, RA patients had more anteriorly positioned maxillae and mandibles, but the differences did not reach a clinically or statistically significant level. In accord with our results, Hu et al. [16] found larger SNA angles in JIA patients. They explained this finding by compensatory ventral growth of the maxilla or the need for a larger functional intraoral space for the growing tongue. They also stated that a smaller SNB angle seems to be the most widespread facial feature in JIA patients with condylar damage. Moroever, in previous studies [22, 24] performed on adult subjects with TMJ osteoarthritis, which is a degenerative joint disease and one of the most common forms of arthritis affecting the TMJ, a smaller SNB angle was a common finding. These conflicting results may be due to the cessation of mandibular growth in the adult patients of our sample.

The maxilla–mandible relationship was assessed by the ANB angle and the Wits appraisal measurements. The values were increased in the RA group, but they did not reach a significant level in our study. Billiau et al. [23] showed that the ANB angle was significantly larger in the JIA group, while Hu et al. [16] showed no significant differences. Twilt et al. [14] stated that retrognathia and posteriorly rotated mandibles were more common in patients with JIA than in the normal population, and this tendency was even stronger if the TMJ was involved. They explained the high prevalence of retrognathia and posterior rotation in all patients with JIA secondary to a negative effect on craniofacial growth caused by the disease itself. Other studies [24, 25] performed on osteoarthritis patients showed increased ANB angles. This lack of consistency may be owing to different study techniques and different unspecified patient groups.

Dentoalveolar relationships of RA patients were assessed by the upper incisor–NA and lower incisor–NB angles, upper incisor-NA and lower incisor-NB distances, interincisal angle, and IMPA. Some of these measurements could not be performed because of missing incisor teeth in three patients with RA and one control subject. These tracing values that were excluded from the statistical analysis are not believed to have affected the study results. The results revealed that RA patients had more retrusive upper and lower incisors and a more obtuse interincisal angle. In contrast with our results, smaller interincisal angles were reported in JIA patients [16, 21, 23]. In accord with our results, more retroclined lower

Table 1 Characteristics of RA patients and control subjects

	RA (*n*=27)	Control (*n*=25)
Age (years, mean±SD)	45.77±8.64	44.80±8.24
Sex (male/female)	2/27	2/25
Disease duration (years, mean±SD)	5.52±4.37	–
Laboratory tests		
RF+	17/27(62.96 %)	
High ESR	14/27(51.85 %)	
High CRP	6/27 (22.22 %)	
ACPA+	16/27 (59.26 %)	
DAS 28		
Low activity (≤ 3.2)	2/27 (7.40 %)	
Medium activity (>3.2–5.1)	24/27 (88.90 %)	
High activity (>5.1)	1/27 (3.70 %)	

SD standard deviation; *DAS* disease activity score; *ACPA* anti-citrullinated peptide antibodies

incisors were reported in patients with TMJ osteoarthritis [24, 26]. This tendency for retrusion of the lower incisors may have been due to the missing incisor teeth and of the resultant tipping and movements of the posterior teeth to the toothless region in patients with RA.

Rotation of the mandible was assessed in RA patients using SGn–SN (Y-axis) and SN–GoGn angle measurements; the difference found between the groups in this study was not significant. Especially in patients with JIA, posterior rotation of the mandible is reportedly a common finding [14, 21]. In the childhood and adolescence periods, JIA patients had a steeper mandibular plane angle and posterior rotation of the mandible as a result of degenerative changes in TMJ [14, 22]. This conflicting result may be explained by the chronological age of our adult sample. All patients in our study were adults, and this may be the reason for the normodivergent mandibular plane angle.

The vertical dimensions of the face of the RA patients were assessed by midface length, mandibular body length, ramus height, posterior face height, and anterior face height. Statistically significant differences between the groups were seen only for the midface length (Co–A; millimeter) measurement. Sidiropoulou-Chatzigianni et al. [21] showed that the lower facial height was increased and the growth pattern of the face was biased toward the vertical direction in children with JIA compared with controls. Previous studies performed on JIA patients reported a short mandibular ramus height and a smaller mandibular body length and posterior face height [22, 23, 27]. Arnett et al. [28] suggested that adult patients with condylar resorption might

Table 2 Dentofacial measurements on cephalometric tracings

	RA			Control			
Variable	*n*	Mean	SD	*n*	Mean	SD	*p* (*t* test)
SNA (degrees)	27	82.07	3.97	25	80.85	2.63	0.201
SNB (degrees)	27	79.20	4.93	25	78.64	2.46	0.607
ANB (degrees)	27	2.88	2.81	25	2.22	1.82	0.324
Wits appraisal (mm)	27	−0.87	3.57	25	−0.73	2.64	0.869
Maxillary skeletal (A–Na Perp) (mm)	27	2.32	4.03	25	1.76	3.37	0.588
Mand, skeletal (Pg–Na Perp) (mm)	27	1.27	7.99	25	1.34	5.57	0.971
U1–NA (mm)	25	3.36	3.5	24	5.15	2.54	0.047*
U1–NA (degrees)	25	17.15	9.22	24	22.21	6.4	0.031*
L1–NB (mm)	26	4.40	2.8	25	5.14	2.01	0.286
L1–NB (degree)	26	22.42	7.06	25	26.36	5.32	0.030*
IMPA (L1–MP) (degrees)	26	87.08	7.01	25	93.58	6.68	0.001**
Interincisal angle (degrees)	24	136.63	13.44	24	128.9	8.72	0.022*
Y-axis (SGn–SN) (degrees)	27	68.74	5.07	25	69.02	3.36	0.817
SN–GoGn (degrees)	27	33.00	7.43	25	31.14	6.1	0.330
Midface length (Co–A) (mm)	27	88.10	3.67	25	85.86	3.66	0.033*
Mandibular body length (Go–Gn) (mm)	27	86.72	5.99	25	84.54	6.36	0.208
Ramus height (Ar–Go) (mm)	27	48.43	4.42	25	49.72	4.57	0.304
Posterior face height (SGo) (mm)	27	80.01	4.91	25	81.39	5.75	0.357
Anterior face height (NaMe) (mm)	27	126.22	6.37	25	124.34	5.92	0.276
Soft tissue convexity (degrees)	27	132.49	8.49	25	131.3	5.09	0.549

SD standard deviation; *NS* non-significant

*$p<0.05$, **$p<0.01$

exhibit a decreased ramus height and progressive mandibular retrusion. Previous studies [24, 25] on adult patients with osteoarthritis showed significantly shorter posterior facial height, decreased ramus height, and progressive mandibular retrusion. The decrease in the ramus height and posterior face height in our patients is thought to be related to the condylar resorption as it was determined in patients with JIA and in those with osteoarthritis.

The surface of the mandibular condyle at the TMJ is covered with cartilage, where hyperplasia, hypertrophy, and endochondral replacement occur [29]. The most important site of growth of the mandible in the vertical and sagittal directions is located on the articular surface of the condylar head. During normal growth of the dentomaxillary complex, the vertical dimension increases more than the sagittal dimension. Arthritis of the TMJ results in reduced mandibular growth and subsequent alteration in the dental occlusion and may even affect the total craniofacial growth [6, 7, 11, 14] but the growth potential of the condylar cartilage should compensate for the condylar resorption and prevent posterior rotation of the mandible and related retrognathia in adult RA patients. The shortened midface length and retrusive upper and lower incisors observed in RA patients, should be taken into account during orthodontic treatment planning, especially in cases of skeletal compensation.

One limitation of this study is that because the dentofacial characteristics of the adult patients with RA have never been evaluated by previous studies, we discussed our results with respect to those of previous reports performed on patients with JIA and patients with osteoarthritis. Another limitation is that the study group comprised adult patients, most of whom had medium disease activity, and they were treated and controlled regularly by a rheumatologist; different results may be obtained by studying a group with high disease activity.

Conclusions

This controlled, clinical, and radiological study showed that the dentoalveolar effects of RA on dentofacial morphology are more significant than the skeletal effects. Clinicians should consider the fact that RA-associated dentoalveolar changes can be observed and may affect the orthodontic treatment process. Future studies with larger sample sizes are required to evaluate the exact effects of RA on dentofacial morphology.

Conflict of interest The authors declare that they have no conflict of interest.

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