ORAL SURGERY
ORAL MEDICINE
ORAL PATHOLOGY

ORAL AND MAXILLOFACIAL SURGERY Editor: Larry J. Peterson

Observer consistency in radiographic assessment of condylar resorption

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Objectives. This study evaluates interobserver and intraobserver agreement with respect to the determination of the shape and surface of the condylar head on panoramic views.
Study design. Detailed frames (n = 632) were made from preoperative and postoperative panoramic views of 158 consecutive patients, who underwent orthognathic surgery. The intraobserver and interobserver agreement were calculated by using Cohen's κ.
Results. By using Cohen's κ, the intraobserver agreement was determined to be reasonable or good for surface and shape of the condyle. The interobserver agreement was mediocre or poor for surface and shape of the condyle.
Conclusion. Because of the subjectivity of using panoramic views to determine the shape and surface of the condylar head, considerable interobserver disagreement is possible.
(Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2002;93:399-403)

One need only review the oral and maxillofacial surgery literature in the last decade to see that condylar resorption and condylar atrophy are significant problems. Condylar resorption is considered an ongoing process that halts when condylar atrophy has been reached. Condylar resorption may cause important clinical changes which make the long-term stability of orthognathic surgery in certain specific deformities unpredictable.[1] Although some difficulties exist with respect to the formulation of a clear definition of condylar resorption, there is consensus about this condition in that it occurs mainly in young women with a high angle mandibular deficiency.[2]

These phenomena are diagnosed or investigated after the occlusal stability and with the aid of sequential conventional radiography, which suggests a reliable, reproducible, and well-accepted method of determining the shape and volume of the condyle.

The panoramic view has been advocated by many authors[3,4] as a good imaging modality when evaluating the temporomandibular joint. Only gross osseous changes can be identified on the panoramic view.[3] The panoramic view is still the most widely taken conventional x-radiograph for general use in oral and maxillofacial practice. Some bias may occur when radiographs taken preoperatively and 1-year postoperatively are judged by investigators who know the clinical result and sequence of radiography.

In this study, we define a radiographic classification of the shape and surface of the condylar head. To assess the reproducibility and the reliability of panoramic view of images made by means of panoramic views, the interobserver and intraobserver agreement variability were determined.

MATERIAL AND METHODS

Patients

This study was conducted in the Department of Oral and Maxillofacial Surgery, University Hospital Vrije Universiteit, Amsterdam, The Netherlands. All patients had a high mandibular angle and absolute mandibular retrognathia as defined by Tuinzing et al,[5] and thus were likely to have condylar changes preoperatively or

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Received for publication Nov 30, 2000; returned for revision Jan 11, 2001; accepted for publication Nov 8, 2001.

1079-2104/2002/$35.00 + 0 **7/12/121706**
doi:10.1067/moe.2002.121706

Table I. Distribution of the shape of the condyles in different categories, for observer I

Assessment 2	*Normal*	*Atrophic*	*Ventral lipping*	*Dorsal-bended*	*Unclear*	*TOTAL n = 632 (100%)*
Assessment 1						
NORMAL	290(45.9)	28(4.4)	9(1.4)	7(1.1)	4(.6)	338(53.5)
Atrophic	52(8.2)	118(18.7)	21(3.3)	16(2.5)	13(2.1)	220(34.8)
Ventral lipping	5(.8)	7(1.1)	25(4.0)	2(.3)	2(.3)	41(6.5)
Dorsal- bended	3(.5)	3(.5)	7(1.1)	6(.9)	0(0.0)	19(3.0)
Unclear	2(.3)	3(.5)	0(0.0)	1(.2)	8(1.3)	14(2.2)
TOTAL	352(55.7)	159(25.2)	62(9.8)	32(5.2)	27(4.3)	632(100)

Intraobserver variability was calculated by using the κ formula: κ =(Po–Pe)/1–Pe), in which *P,* proportion; *o,* observed, *e*, expected by chance. κ (shape)(I;1,2) = 0.52.

Table II. Distribution of the surface of the condyles in different categories for observer I

Assessment 2	*Smooth*	*Irregular*	*Unclear*	*Total n = 632(100%)*
Assessment 1				
SMOOTH	408(64.6)	12(1.9)	36(5.7)	456(72.2)
IRREGULAR	23(3.6)	58(9.2)	21(3.3)	102(16.1)
Unclear	10(1.6)	10(1.6)	54(8.5)	74(11.7)
TOTAL	441(69.8)	80(12.7)	111(17.5)	632(100)

κ = 0.61 (surface).

postoperatively. All patients were treated either with a bilateral sagittal split osteotomy or a bimaxillary osteotomy procedure (ie, a LeFort I osteotomy). The patients were consecutively treated.

After presurgical orthodontic treatment, preoperative panoramic radiographs were taken. All the radiographs were taken on the same equipment (Siemens Orthophos) by using regular patient positioning. Postoperative panoramic radiographs were taken one year after surgery. Standard detailed frames were made of the condyle area in which the condylar head, the articular eminence, and the upper part of the ascending ramus could be seen. The x-rays were anonymously assessed, and the detailed frames were numbered 1 through 632. To analyze the detailed frames, categories were defined by 5 different standard drawings used as a template to determine the detailed frames, as follows: 1 was regarded as *normal*; 2 was regarded as *atrophic*; 3 was regarded as *ventral lipping*; 4 was regarded as a *dorsal-bended condyle*; and 5 was regarded as *unclear*.

A normal condyle head was thought to consist of a smooth-surfaced condyle and a height/width ratio equal to 1. *Atrophy* was defined as a condyle head with decreased volume and short distance to the mandibular notch. *Ventral lipping* was defined as a clear osteophytic bone formation on the anterior side of the condyle head.

Dorsal bending was defined as a posteriorly inclined upper ascending ramus with an atrophic condyle head. Categories 2, 3, and 4 were regarded as typical deviating shapes of the condyle head. In the case of a condyle exhibiting features of more than one category, the most evident category was chosen. The observers had consensus about the categories.

To measure the interobserver and intraobserver agreement with respect to the shape and the surface of the condyle head, Cohen's κ was used in which a score of 0.41 or higher was considered reasonable agreement.[6,7]

Landis and Koch[7] use the following scale for intraobserver and interobserver agreement: <0.00, *poor*; 0.00 to 0.20, *slight*; 0.21 to 0.40, *mediocre* (*moderate*); 0.41 to 0.60, *reasonable* (*substantial*); 0.61 to 0.80, *satisfying* (*good*); and 0.81 to 1.00, *almost perfect*.

RESULTS

Intraobserver variability

The 632 detailed frames were assessed for surface and shape twice, by 3 (I, II, III) observers. The interval between the first and the second assessment was at least 3 weeks to prevent the determination of the condyles being influenced by recollection. The distribution in the different categories with respect to shape and surface can be seen in Table I and Table II. Table I shows the distribution of the shape, and Table II shows the distribution of the surface.

Table I shows that, in the first assessment, 338 (53.5%) condyles were considered normal and, in the second assessment, 352 (55.7%) condyles were considered normal. The greatest variation between the first and second assessment was in the determination of atrophic and normal. Of the 338 normal condyles in the first assessment, 28 were atrophic in the second assessment. Of the 352 normal condyles in the second assessment, 52 were atrophic in the first assessment. Therefore, in 80 cases there was uncertainty about the condyle.

Table II shows the first and second assessments of observer I. In this distribution there are 456 condyles with a normal smooth surface in the first assessment of observer I. In the second assessment there are 441 condyles with a normal smooth surface.

In the first assessment there are 74 assessments categorized as unclear versus 111 in the second assessment. It is unclear why 37 pictures in the second assessment were not categorized, whereas in the first assessment they were categorized as *irregular* or *smooth*. Table III shows all the intraobserver κ values of the shape.

The Cohen's κ of each observer between the first and the second assessment is ≥0.41; thus there is a reasonable or better intraobserver variability. This counts for the surface and the shape. Observer II had the highest Cohen's κ (0.67 for surface and 0.64 for shape), and observer III had the lowest (0.44 for surface and 0.41 for shape).

Table III. The intraobserver variability (κ) of observers I, II, and III during assessments 1 and 2

	κ
κ; $\text{shape}_{(I;1,2)}$	0.52
κ; $\text{shape}_{(II;1,2)}$	0.64
κ; $\text{shape}_{(III;1,2)}$	0.41

Interobserver variability

The 632 detailed frames were assessed in terms of surface and shape. The agreement between the different observers was calculated by using the κ formula. The distribution of the first assessment, observer I versus observer II, can be seen in Table IV. Table IV shows that the first observer categorized 338 condyles as "normal" and the second observer categorized 357 condyles as "normal."

The greatest difference between these 2 observers was in the determination of atrophy and unclear categories (220 vs 50 and 14 vs 131). Thus, these are the categories important for establishing Cohen's κ. In Table V, the 632 detailed frames were assessed with respect to surface and compared between 2 observers (κ [I, II;1] = 0.39 [surface]).

Four of the 24 Cohen's κ values are reasonable. Not one of the κ values is in the category *good* (>0.61) or better. The surface has a higher average κ value than the shape. There is a tendency for the Cohen's κ value to get better for the second assessment.

DISCUSSION

Classifications of pathologic changes of the condylar head are often described. In addition to enabling an analysis of the clinical signs and symptoms, the pantomogram is widely used to determine the condition of the condyles. Other imaging techniques used for the temporomandibular joint include the transcranial view, the transpharyngeal view, conventional tomography, computed tomography, arthrography, and magnetic resonance imaging.[3]

Boering[8] describes the following radiographically visible degenerative changes: flattening of the condyle defined as a loss of the round contour of the condyle on the load-bearing area; surface irregularities, defined as interruptions or depressions of the condylar surface; erosion of the condyle, defined as an interruption or absence of the cortical lining; sclerosis of the condyle, defined as increased density of the cortical lining or the subchondral bone; cyst formation in the condyle, defined as subcortical radiolucencies; exophytes, defined as marginal hypertrophic bone formation; and deviation in shape, defined as any morphologic deviation in the rounded, smooth appearance of the condyle including congenital and severe degenerative lesions.

Gynther et al[9] created a classification of radiologic hard tissue changes that uses criteria such as presence of erosion, flattening, sclerosis, and osteophytes in patients with osteoarthritis. These classifications are based on 2-dimensional reproductions by means of Parma, Schüller, and panoramic views.[8] No validation regarding the reliability and reproducibility of the categories has been received.

Krajenbrink[10] created an 8-scale classification of the condyle head by using the height-to-width ratio and investigating the agreement of 2 observers. The classification of pathologic or deviating forms of the condyle are all in the same category. This theoretical model was validated by both interobserver and intraobserver agreement.

Brooks et al[3] noted that the transcranial view (Schüller) may not reveal subtle osseous changes and the transpharyngeal view was effective for demonstrating destructive changes of the condyle but was less valuable for productive changes. The phenomenon of condylar resorption consists of several parameters such as decreasing posterial facial height, afunctional remodeling of the condylar head, and alteration in occlusion (ie, a more retruded Angle class II occlu-

Table IV. Distribution of the first assessment of observer I and observer II in different categories

Observer II	*Normal*	*Atrophic*	*Ventral lipping*	*Dorsal- bended*	*Unclear*	*Total* *n = 632 (100%)*
ObserverI						
Normal	283 (44.8)	3 (.5)	16 (2.5)	0	36 (5.7)	338 (53.5)
Atrophic	65 (10.3)	40 (6.3)	33 (5.2)	10 (1.6)	72 (11.4)	220 (34.8)
Ventral lipping	5 (.8)	3 (.5)	26 (4.1)	0	7 (1.1)	41 (6.5)
Dorsal-bended	4 (.6)	4 (.6)	7 (1.1)	2 (.3)	2(.3)	19 (3.0)
Unclear	0	0(0.0)	0(0.0)	0	14(2.2)	14 (2.2)
Total	357 (56.5)	50 (7.9)	82 (13.0)	12 (1.9)	131 (20.7)	632 (100)

$\kappa = 0.36$ (shape).

Table V. Distribution of the first assessment with respect to the surface of the condyle head, observer I versus observer II

Observer II	*Smooth*	*Irregular*	*Unclear*	*Total* *n = 632 (100%)*
Observer I				
Smooth	397 (62.8)	15 (2.4)	44 (7.0)	456 (72.2)
Irregular	49 (7.8)	9 (1.4)	44 (7.0)	102 (16.1)
Unclear	16 (2.5)	2 (.3)	56 (8.9)	74 (11.7)
Total	462 (73.1)	26 (4.1)	144 (22.8)	632 (100)

sion).[11-13] In this study, we investigated the feasibility of accurately determining the shape and surface condyles. We attempted to define 3 different deviations from the condyle head and to assess the interobserver and intraobserver agreement by using preoperative and postoperative detailed frames of the condyle head derived from panoramic views. The alteration of the condylar shape and the decrease in mass are two of the characteristics of condylar resorption. However, defining a typical radiographic form and distinguishing between functional remodeling or dysfunctional remodeling is difficult.[13] We used 3 different typical alterations of the normal condyle head described by Boering[8] as a stage of osteoarthrotic changes. The intraobserver agreement was reasonable, in terms of the shape and the surface, according to the scale used by Landis and Koch.[7] The interobserver agreement was poor. The κ value of the surface ameliorates the second assessment, suggesting a learning curve with respect to the surface. The interobserver agreement for the shape doesn't show a tendency to ameliorate. The individual observers were able to consistently observe the detailed frames of the condylar heads, but this was completely subjective. In this study, the true reproduction of the condyle head on the detailed frames was not an important factor—as shown by the results of the interobserver agreement. This would have been an important factor if the interobserver agreement were higher. The accuracy of the intraobserver agreement was subjective but consistent. Whether the results would be better if there were fewer categories or whether the categories were simplified warrants further investigation. To properly diagnose condylar atrophy, more data than those culled from the condylar head alone are necessary—including the location of the lower border of the ramus, the ramus height, and its shape.

CONCLUSION

Whether a panoramic view has any significance in determining the risk of developing condylar atrophy or confirming preexisting condylar resorption is unclear. In this study, the panoramic views appear to have little value in determining the condylar head. There is a need for an objective method to standardize the evaluation of the status of the condyle head. The clinical consequences are substantial.[14-17] The question remains whether condylar resorption has clinical consequences, such as relapse after orthognathic procedure, or whether functional remodeling occurs.[13]

We thank Dr A. G. E. Becking for his contribution to this article and J. Lapar and H. J. Spikman for processing the data.

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