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## FRACTURES OF THE MANDIBULAR CONDYLE IN THE GROWTH PERIOD

### HISTOLOGIC AND AUTORADIOGRAPHIC OBSERVATIONS IN THE CONTRALATERAL, NONTRAUMATIZED CONDYLE

by

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#### INTRODUCTION

Earlier investigations (*Blackwood, 1966, Öberg, 1964*) have demonstrated that the main progenitor cell population to condylar growth is represented by the intermediate cell layer of the condylar growth zone. This cell population is situated between the fibrous covering of the articular surface and the condylar cartilage (Fig. 2). Further, at the present time it is agreed upon that condylar growth follows a pattern of ossification as observed in endochondral bone formation.

Experimental studies have visualized that the condylar growth zone, through altered activities of the proliferative rate in the intermediate cell layer, reacts upon condylar displacement with alterations in condylar growth rate (*Baume & Derichsweiler, 1961; Folke & Stallard, 1966, 1967; Charlier et al., 1969*).

It is noteworthy to observe that an earlier study (*Gilhuus-Moe, 1969*) has revealed that the intermediate cell layer of the condylar growth zone, following subcondylar fracture displacement, reacts to the trauma in the same manner as do any undifferentiated cell population. In this experimental study it was thus observed in young, rapidly growing guinea pigs that a significant increase in cellular proliferation within the intermediate cell

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layer of the condylar growth zone occurred immediately after the fracture displacement. This increase reached a maximum 24–48 hours following the fracture and was followed by a gradual decrease in cellular proliferation through a 4 weeks period.

In this way the intermediate cell layer of the condylar growth zone reacted to trauma in the same way as did the mandibular periosteum. These reactions were similar to those observed in the tibial periosteum following fracture displacement (*Tonna, 1961*). Analogous observations have been made in the periodontal membrane of the guinea pig. (*Johansen & Gilhuus-Moe, 1969*). Following any fracture trauma a distant effect upon cellular proliferation within the periosteum has been observed (*Tonna, 1961; Tonna & Cronkite, 1961; Gilhuus-Moe, 1969*).

The present investigation was performed to observe if alterations in cellular proliferation within the *nonfractured* mandibular condyle occurred following fracture displacement of the contralateral condyle. Cellular reactions within this cellpopulation appear to be of interest following contralateral fracture trauma, since according to *Sicher (1962)* »the temporomandibular joint is a hinge joint with moveable axis«. According to this postulate it appears to be importance to focus interest upon cellular proliferations within a condylar growth zone following injury to the contralateral mandibular condyle.

#### MATERIALS AND METHODS

Young, male guinea pigs approximately 4 weeks of age, were used in this study. The animal population is identical to that described by *Gilhuus-Moe (1969)*. In total 54 animals served as normal (control) animals. These animals were used to obtain an estimate of normal cellular proliferative activity within the intermediate cell layer of the condylar growth zone. In 31 animals subcondylar fractures by an open, percutan approach were performed at the right side. In 7 animals sham operations were performed.

The animals were sacrificed at intervals from 6 hours to 28 days after the fracture. H3 TDR (IMC/g body weight) was administered through an intraperitoneal route 60 minutes prior to sacrifice.

The specimens were fixated in Lavdowskis fixative, and decalcified in 20 % formic acid. The endpoint of decalcification was determined radiographically. Sections were prepared for light microscopic examination and for autoradiographic examination following the dipping method. Kodak nuclear track emulsion (NTB 2) was used. The coated slides were exposed for 24 days, developed and stained with hematoxylin.

In the *present* examination the left noninjured condyle was examined, the number of labelled cells of the intermediate cell layer was registered and the labeling index (Li), — i.e. the number of labelled cells (Ns) in relation to the total number of cells (N) — was determined in each specimen.

#### ANATOMICAL REMARKS

The mandibular condyle of the guinea pig represents the most cranial portion of the mandible. The condyle is roller shaped with the greatest axis in an antero-posterior direction. The anatomical features of the mandibular condyle in frontal sections is shown in Figs. 1 and 3.

The tissue layers of the frontally sectioned condyle are shown in Fig. 2. The major anatomical and histological details of the mandibular condyle in the guinea pig has been reviewed by Öberg (1964).

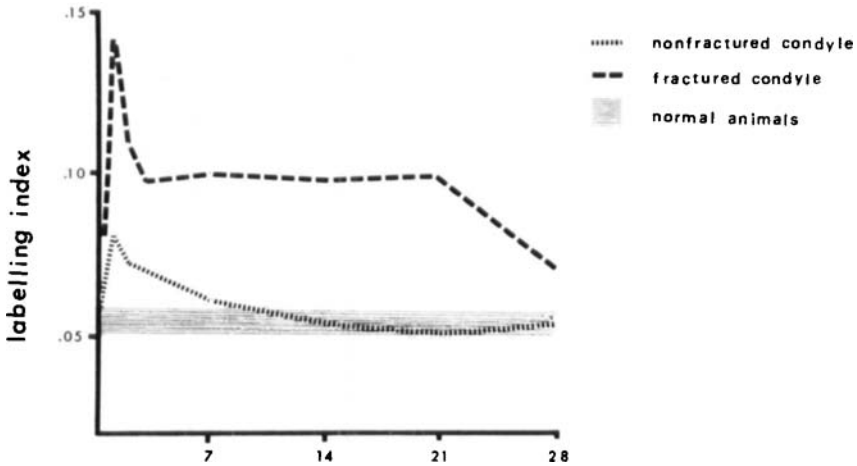
#### OBSERVATION

The distribution of H<sup>3</sup>TDR labelled cells in the intermediate cell layer of the condylar growth zone reveals a constant pattern in the normal guinea pig. (Öberg *et al.*, 1967; Gilhuus-Moe, 1969). Labelled cells are exclusively observed in this cell layer of the condylar growth zone, following a 60 minutes interval between isotope injection and sacrifice («flash-labeling») Fig. 4.

If labelled cells of the intermediate cell layer are recorded to semischematic tracings, according to a plane of sectioning revealed in Fig. 1, this distribution in a normal animal is demonstrated in Fig. 7. The labelling index of the intermediate cell layer of the normal control animal is estimated at  $0.054 \mp 0.005$  (Text Fig. 1).

Following a fracture trauma of the right mandibular condyle, considerable alterations were observed in the intermediate cell layer of the *contralateral left condyle*. In this area, 24 hours after the fracture, a definite increase both in total and relative number of labelled cells was observed. The sequence of observations is shown in Figs. 8—12 and Table I.

The increase in number of labelled cells, with the corresponding increase in labeling index revealed a sharp peak within the first 24—48 hours after the trauma, returning to values similar to those observed in the normal animals 5—7 days after the fractures. It can thus be postulated that the proliferative activity of the noninjured condyle is parallel to that of the fractured, displaced contralateral mandibular condyle.



Text Fig. 1. Mean labelling index of the intermediate cell layer of the condylar growth zone.

It was of interest to observe that the light microscopic examination to some extent demonstrated these tissue reactions. An increased width of the intermediate cell layer was thus observed (Fig. 6). The cells had lost their flattened appearance and turned into a cuboidal shape.

Table I.

*Labelling index of the intermediate cell layer of the condylar growth zone*

$$\text{Labelling index } (L_i) = \frac{\text{Number of labelled cells } (N_s)}{\text{Total number of cells } (N)}$$

Postfracture period	N	Ns	$L_i$
24 hours	1573	128	.081
48 hours	1263	91	.072
7 days	1166	70	.060
14 days	1232	69	.056
21 days	1200	60	.050
28 days	1018	55	.054

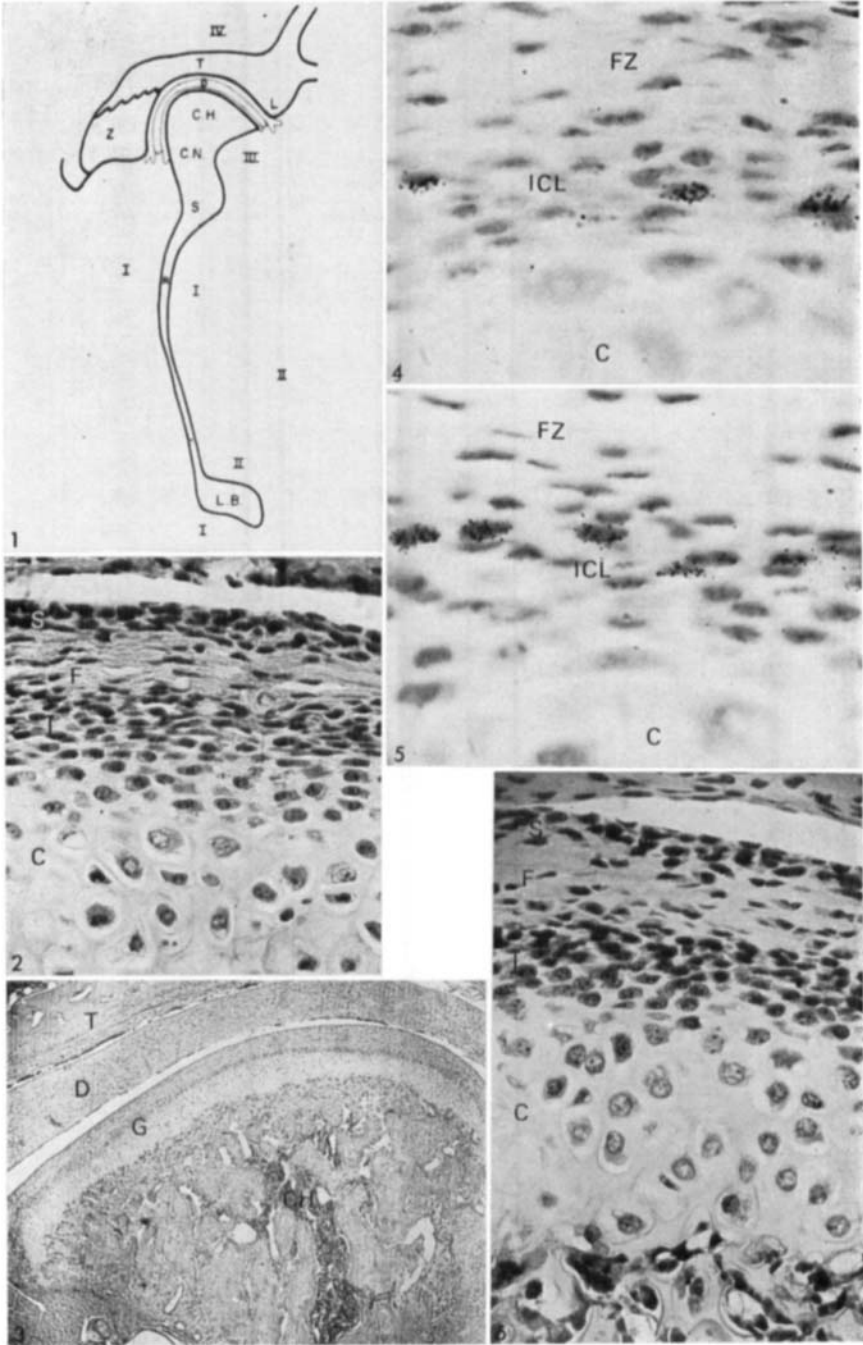


Fig. 1. Schematic tracing right mandibular joint

- T: Articular fossa
- D: Articular disc.
- Z: Zygomatic arch.
- C.H: Condylar head
- E.N: Condylar neck
- S: Subcondylar region
- R.L.B: Ramus and lower border of mandible
- I, II, III, IV: Masticatory muscles.

Fig. 2. Tissue layers of the left mandibular condyle, (H + E  $\times$  280)

- S: Superficial cell layer
- F: Fibrous cell layer
- I: Intermediate cell layer
- C: Cartilage.

Fig. 3. Left temporomandibular joint, (H + E  $\times$  30)

- T: Temporal bone
- D: Articular disc.
- G: Condylar growth zone
- C.H: Condylar head

Fig. 4. Left condylar growth zone of normal (control) animal. (Autoradiograph  $\times$  700)

- F.Z: Fibrous cell layer
- I.C.L: Intermediate cell layer with H3TDR labelled cells
- C: Cartilage

Fig. 5. Left condylar growth zone. Experimental animal. 24 hours following subcondylar fracture displacement of the right (contralateral) mandibular condyle. (Autoradiograph  $\times$  700)

- F.Z: Fibrous zone
- I.C.L: Intermediate cell layer
- C: Cartilage

Fig. 6. Tissue layers of the left mandibular condyle 48 hours following fracture displacement of the contralateral condyle. Observe increased width of the intermediate cell layer. The cells have lost their flattened appearance and turned into a cuboidal shape.

- S.: Superficial cell layer
- F.: Fibrous cell layer
- I.: Intermediate cell layer. Observe increase in width of cell layer
- C.: Cartilage

Fig. 7—12. Tracings: Distribution of H3TDR labelled cells in the growth zone of the left mandibular condyle. Each point represents two labelled cells.

Fig. 7. Normal (control animal)

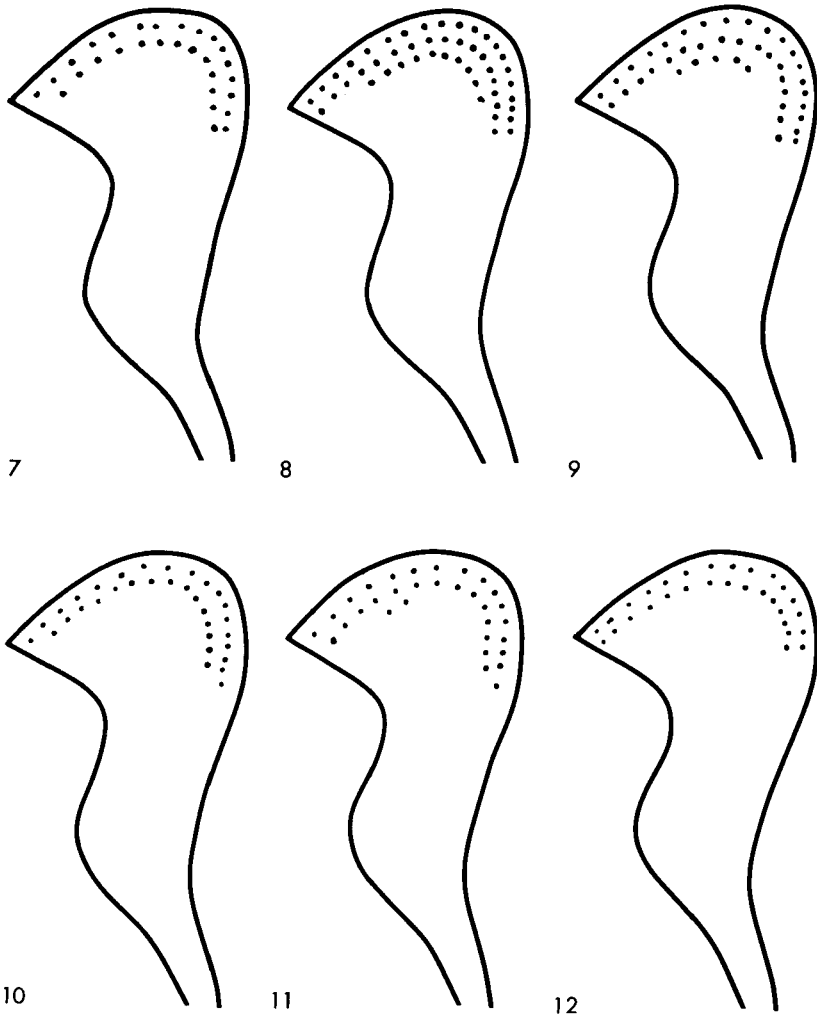
Fig. 8. 24 hours after fracture displacement of the contralateral fracture.

Fig. 9. 48 hours after fracture displacement of the contralateral fracture.

Fig. 10. 7 days after fracture displacement of the contralateral fracture.

Fig. 11. 14 days after fracture displacement of the contralateral fracture.

Fig. 12. 21 days after fracture displacement of the contralateral fracture.



DISCUSSION

From a morphological point of view, histologic examination has given valuable information concerning mandibular and condylar growth and remodeling (*Walker, 1960; Boyne, 1967; Gilhuus-Moe, 1969*).

In the present examination flash-labeling technique has been used, i.e. a method giving an image of cellular kinetics within a cell population at the time of sacrifice. Through earlier examinations using this particular method (*Folke & Stallard, 1966; Charlier et al., 1969*) it has been demonstrated

that condylar displacement by means of orthodontic devices, initiates increased cellular turn-over within the cell population of the intermediate cell layer. An analogous, however, a much more marked elevation in proliferative rate, is observed within the same cell population following subcondylar fracture with displacement of the mandibular condyle (*Gilhuus-Moe, 1969*). These reactions of the intermediate cell layer demonstrate capacities similar to those of any undifferentiated cell population.

According to present concepts, the condylar growth zone contributes to mandibular bone growth by endochondral bone formation. This growth is initiated through proliferation of the intermediate cell layer. As a natural consequence, increased proliferation in this progenitor cell population is followed by morphological change within the chondroblastic and chondrocytic cell layers. The observed increase in width of the »epiphyseal-like» condylar cartilage following condylar fracture displacement (*Gilhuus-Moe, 1969*), and condylar propulsion also (*Charlier et al, 1969*), could be demonstrated to a less extent in the contralateral, nonfractured mandibular condyle. The increase in mitotic activity of the intermediate cell layer of the condylar growth zone was parallel both at the fractured side and the contralateral nontraumatized side (Text Fig. I). At both sides an initial sharp increase followed by a mild decrease in mitotic activity could be revealed.

This rapid reaction in the »nontraumatized» condyle differs definitely from the rather slow reaction as demonstrated by *Folke and Stallard* (1966) following condylar propulsion in the rat. This reaction within the condylar growth zone of the »nontraumatized» condyle, suggests that very rapid alterations in fossa-condyle relations occur in the temporomandibular joint contralateral to the joint suffering from condylar fracture displacement.

It appears reasonable to accept that the condylar growth zone in the guinea pig reacts to fracture trauma by alterations in mitotic activity, a reaction occurring both at the fractured as well as in the nonfractured condyle. The latter reaction appears to be related to the altered anatomical relations between mandibular condyle and articular fossa. It might thus be concluded that even minor traumas initiate rapid, observable alterations in mitotic activity. These reactions should be related to ordinary adaptive responsive in any membrane bone, and support the thesis of a high degree of adaptability of the mandibular condyle to traumatic lesions.

#### SUMMARY

This study was performed to investigate the cellular reactions within the intermediate cell layer of the mandibular condyle in young guinea pigs

following fracture displacement of the contralateral condyle. For this reason autoradiography with tritiated thymidine ( $H^3TDR$ ) was used. It was thus observed that unilateral condylar fracture displacement initiated a rapid increase in proliferative activity of the fractured condyle as well as in the contralateral, nonfractured condyle. The increased mitotic activity followed the same pattern in the condylar growth zones at both sides and these reactions were similar to those observed in any mesenchymal cell population following trauma. It was assumed that these observations of the proliferative activity in this particular cell population are related to the pronounced adaptability to traumatic lesions observed in the mandibular condyle.

#### RÉSUMÉ

FRACTURES DU CONDYLE MANDIBULAIRE PENDANT LA PÉRIODE DE CROISSANCE  
OBSERVATIONS HISTOLOGIQUES ET AUTORADIOGRAPHIQUES DANS LE CONDYLE  
CONTRO-LATÉRAL, NON TRAUMATISÉ

Ce travail a été effectué dans le but d'étudier les réactions cellulaires se produisant à l'intérieur de la couche cellulaire intermédiaire du condyle mandibulaire chez de jeunes cobayes après fracture avec déplacement du condyle opposé. Ceci a été fait par autoradiographie en utilisant la thymidine tritiée ( $H^3TDR$ ). On a ainsi observé que la fracture unilatérale du condyle avec déplacement provoque une rapide augmentation de l'activité proliférative, tant dans le condyle fracturé que dans le condyle opposé, non fracturé. L'activité mitotique augmentait suivant le même plan dans les zones de croissance condyliques des deux côtés, et ces réactions étaient semblables à celles que l'on observe dans n'importe quelle population cellulaire mésenchymateuse après traumatisme. Il est à supposer que ces observations sur la prolifération ayant lieu dans cette population cellulaire particulière sont liées à la notable adaptabilité aux lésions traumatiques que l'on observe dans le condyle mandibulaire.

#### ZUSAMMENFASSUNG

FRAKTUREN DES KIEFERGELENKFORTSATZES WÄHREND DES WACHSTUM  
HISTOLOGISCHE UND AUTORADIOGRAPHISCHE BEOBACHTUNGEN IN DEM  
ENTGEGENGESETZTEN, GESUNDEN GELENKFORTSATZ

Diese Untersuchung wurde ausgeführt um die zelluläre Reaktionen innerhalb des intermediären Zellschichtes im Kiefergelenkkopf von Meerschweinchen

zu studieren, deren entgegengesetzte Processus condylaris aus ihrer Gelenkpfanne frakturiert wurde.

Hierzu wurde Autoradiographie benutzt, ausgeführt mit radioaktivem Thymidin (H<sup>3</sup>TDR). Es wurde gefunden, dass eine einseitige Gelenkfortsatzfraktur eine vermehrte proliferierende Aktivität im Gange setzte sowohl auf dem verletzten als auch auf den gesunden Gelenkfortsatz. Die vermehrte mitotische Aktivität folgte beiderseits dasselbe Muster, und diese Reaktionen ähnelten diejenigen die man in jeder mesenchymaler Zellansammlung auf Grund einer Schädigung findet.

Es wurde angenommen, dass die Observationen, die proliferierende Aktivität in dieser speziellen Zellansammlung ergaben, mit der ausgesprochenen Anpassungsfähigkeit des Kiefergelenkfortsatzes an Verletzungen verwandt sind.

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