Shout Communication

Quantitative analysis on ESFs (elastic system fibers) of TMJ using image processing

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Introduction

It is well known that the ESFs (elastic system fibers) play an important part in the retrusive movement of the disc during jaw closure¹⁻³⁾. Therefore, it is important to determine the kinetic relationship between the growth and aging of ESFs. However, it is difficult to analyze the dynamics of ESFs, because the properties of ESFs change with the volume, distribution, number and density of the fibers.

In the present study, therefore, the video-scanning image analyzing technique is used for the quantitative measurement of ESFs in the aging of the mandibular condyle.

Materials and Methods

The head portion, including the mandibular joint, was obtained from JCL/ICR mice aged 1 day and 1, 2, 4 and 10 weeks after birth. The samples were fixed in 10% formalin, rinsed in running water, then dehydrated in a series of gradual ascending degrees of alcohol, each step for approximately one hour. This was followed by substitution with xylene. Subsequently, the

samples aged 4 and 10 weeks were soaked in the Plank Rychlo decalcification solutions⁴⁾. After decalcification, the head portions were washed in running water for 6 to 24 hours to remove the last traces of the decalcification solution ; all of the samples were embedded in paraffin following the conventional method. The specimens were sectioned with a steel knife mounted on a microtome at a 5 μ m thickness. The frontal sections were mounted on slide glasses, and stained with both the Weigert's resorcin fuchsin preoxidation method and the aldehyde fuchsin preoxidation method (used for selecting oxytalan, elaunin, and elastic fibers) ; preoxidation was performed in a solution containing 0.3% H₂SO₄ and 0.3% sulfuric acid for 30min⁵⁾.

Some sections were stained to differentiate elaunin and elastic fibers from oxytalan fibers using the Weigert's resorcin fuchsin method without preoxidation. Furthermore, the aldehyde fuchsin method without preoxidation and the Verhoeff's haematoxylin staining were conducted for the selection of elastic fibers.

For quantitative analysis, the amount of the fibers was determined with the image analyzer system XL-500 (Biological microscope BH-2, Olympus ; TV-

Fig. 1 Diagram of image processing.

camera FCD-725, Olympus-Avio; Personal Computer PC-9801, NEC). The objects under specially selected illumination were scanned and focused by the TV camera and lens, then the focused image was converted to an electric signal. The electric signal was sequentially scanned with the relative electronic beam, which was amplified to produce the most reliable electric signal.

Then, the following procedure was designed to obtain various data regarding the numerical quantity, area and diameter of the relative object after treatment and the analysis of the electric signal which was produced from the photo electric converter. The original shaded image was generated and converted by the photo electric converter and filtered by the input slope (detecting sensitivity) to detect the relative figures. By input contrast, the figure was shown to have a secondary image in black and white. After the black and white secondary imaging was revealed, suitable compensation was then made to eliminate electric noise or dust by input size discrimination. The display shows the measured and counted data, and at the same time the data obtained was automatically printed out for recording (Fig. 1).

Measurements were made on every 5 sections of the central portion of the TMJ which were determined by counting the sections containing the condyle; 6 condyles per age group were studied. The ESFs in the lateral aspect of the TMJ, containing the lateral part of the articular disc, lateral extension of the lower articular cavity and its surrounding tissues, were quantitatively analyzed (Fig. 2 and 2a).

Results and Discussion

ESFs contain 4 types of fibers: the oxytalan, elaunin, preelastic and elastic fibers as differentiated by Gawlik⁶. Cotta-Pereira et al.⁷, in addition, have identified oxytalan, elaunin, and elastic fibers in their electronmicroscopic study. The same study also elucidated that sequential developmental phases of the elastic fibers include the younger elastic fibers (oxytalan), the premature elastic fibers (elaunin) and the fully mature elastic fibers (elastic). However, Hanji⁵ demonstrated that oxytalan fibers never develop into characteristic elastic fibers. In the present study, the authors conducted conventional light microscopy on the ESFs using the Weigert's resorcin fuchsin methods, the aldehyde fuchsin methods and Verhoeff's haematoxylin elastic fiber stain. The results revealed the existence of three types of fibers; oxytalan, elaunin, and elastic fibers.

Quantitative analysis has shown that the elastic fibers have a direct relationship with the elaunin fiber. Subjects at one week of age showed the largest number of elaunin fiber. After one week, and inverse proportion between the increasing number of elastic fibers and decreasing number of elaunin fibers was evident. In our previous study, Tsubai⁸ has also observed that the distribution of the elaunin fibers changed with that of elastic fibers after birth.

These results suggested that a part of the elaunin fibers do develop into elastic fibers. However, the number of oxytalan fibers increased very little to show a significant change. Sims⁹ has stated that the oxytalan fiber system of functioning teeth possessed a high degree of permanence and was metabolically distinct from collagen and elastic fibers; the oxytalan fibers showed different properties from the elaunin and elastic fibers.

Griffin et al.¹⁰ has stated that a few elastic fibers in the posterior portion of the human temporomandibular joint (TMJ) play a role in maintaining the normal positional relation of the articular disc particularly during the retrusive movement of the mandible, by means of an adjustment of the masticatory muscle movements. We postulate that if the elastic fibers

Fig. 2 The secondary image (an area in Fig. 2a) showing brilliant ESFs in the TMJ at the 1th week of age. (Weigert's resorcin fuchsin preoxidation method bar : 50 μ m, MC : Mandibular Condyle)

Fig. 3 Graph showing the relation between the growth and the number of ESFs. Each value and vertical bar represent mean $\pm$ SD

gave positive aid in preventing damage during excessive excursion, the number of the elastic fibers would increase. However, on the contrary, the present study on the aging of the mandibular joint shows that the

elastic fibers decrease with an accompanying increment of collagen fibers between the 2nd to 4th weeks after birth. The present study also elucidates that the elastic fibers, particularly in the lateral portion of the

articular disc, are not the main stressbearing fibers concerning the masticatory function of the TMJ tissues. Therefore, we postulate that the elastic-fiber network is mainly a supplemental structure to support the collagen compartment in this region.

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