

# The articular disc surface in different functional conditions of the human temporomandibular joint

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The peripheral discal tissue and the surface covering layer have been studied in normal and in variously damaged human temporomandibular joint discs. In the normal disc the tissue consisted of dense bundles of fibers and rare fibrocytes. The surface of the disc was covered by a regular basophilic and electron-dense layer. These morphological characteristics persisted also in some pathological discs in which fibrous derangements had already occurred in the deep parts. In very deformed and damaged discs associated with serious functional anomalies, the superficial discal tissue consisted of rare fibers dispersed in a loose ground substance and of an increased number of cells. The superficial coating was formed by an irregular dense lamina and aggregates of various materials containing cellular debris, vesicles, filaments and amorphous components. These deposits are probably due to degeneration processes of discal tissue. This investigation suggests that the superficial discal tissue and the covering layer are together involved in maintaining the functional properties of the articular surfaces. Their structural modification in severe functional anomalies leads to failure in the maintenance of nonadherence conditions and to deterioration of the functional defect.

Key words: articular disc; articular surface; functional anomalies; morphology; temporomandibular joint

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The articular disc is a structural component of the temporomandibular joint (TMJ). The main function of the disc is the absorption of compression loads from the mandible for protection of the thin temporal bone of the mandibular fossa. The articular disc is a fibrous tissue composed of bundles of collagen fibers embedded in a ground substance with a few fibrocyte- or fibroblast-like cells (1, 2).

Derangements of the collagenous fiber network, vascularization of the central avascular part of the disc and modifications in the cellular component are the main structural changes observed in articular discs following different temporomandibular joint dysfunction syndromes (3-11).

In previous studies attention was fo-

cused on the structural characteristics of the surfaces of the articular discs (12, 13). These emphasized the importance of the articular fibrous tissue in maintaining an intact articular surface and in absorbing frictional effects during articular movements. Moreover, the important role of the superficial proteoglycan lamina in regulating the exchange of molecules between the disc surface and the synovial fluid has been recently underlined (14). These movements of molecules are necessary for load-bearing properties and lubrication of the articular surfaces.

The aim of this study was to investigate the light microscopical and ultrastructural characteristics of the surface of the articular disc in order to correlate the morphological changes to the func-

tional condition of the joint and to suggest possible clinical implications.

## Material and methods

Observations were performed on 10 discs removed from patients suffering from TMJ dysfunctions and on one healthy disc obtained at autopsy from a young subject without TMJ diseases in his clinical history. The 10 discs were selected among a larger number of cases in order to examine discs that presented very variable macroscopic features due to different alterations of TMJ function.

After dissection, the central part of each disc (for detailed description see 8-11) was excised, reduced to small pieces and immediately fixed with a

Fig. 1. Electron micrograph of the superficial region in the healthy control disc. Parallel, dense bundles of collagen fibers and interposed fibrocytes are present. The disc surface is covered by a subtle electron-dense surface lamina (arrows). ( $\times 4000$ )

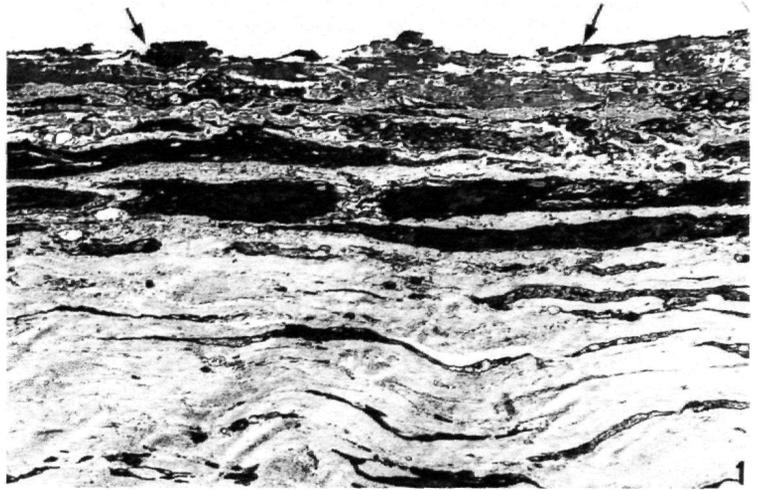


Fig. 2. Electron micrograph of a slightly damaged disc. The superficial region occasionally develops protuberances that are covered by the electron-dense surface lamina (left arrow). ( $\times 4000$ )

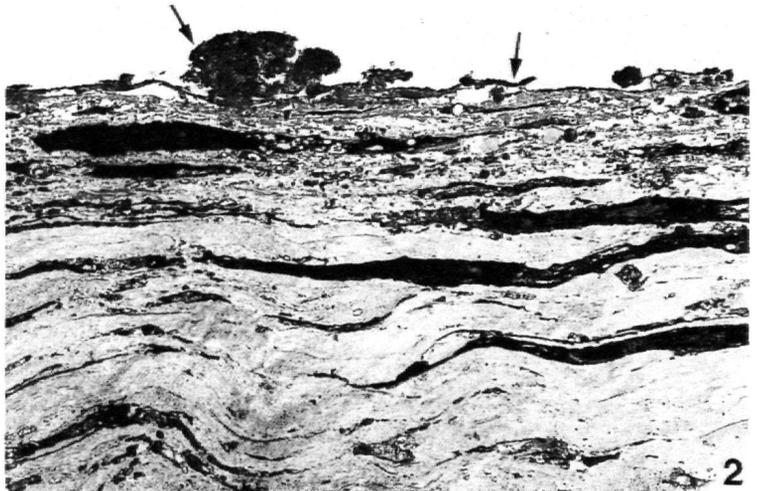
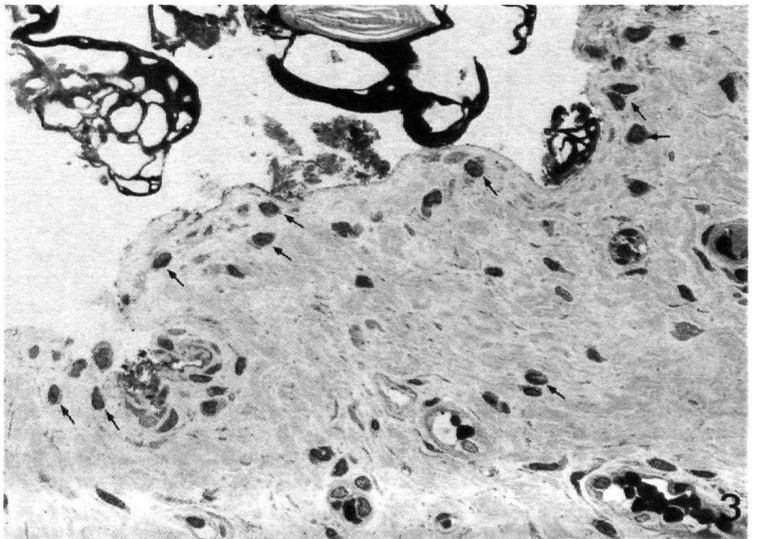


Fig. 3. Light micrograph of a damaged disc. The superficial discal tissue is composed of a loose connective tissue matrix containing round or oval cells (arrows). Prominent aggregates of basophilic material are present over the superficial surface layer. ( $\times 500$ )



fixative solution of glutaraldehyde (2.5%) and paraformaldehyde (2%) in 0.1 M sodium cacodylate buffer (pH 7.4) for 5 h at 4°C. The specimens were post-fixed in 0.1 M OsO<sub>4</sub> in 0.2 M collidine buffer (pH 7.4) for 2 h at 4°C, dehydrated and embedded in epoxy resin. Semithin sections (0.5 µm) for light microscopy were stained with toluidine blue and ultrathin sections (80 nm) for transmission electron micro-

scopy were contrasted with uranyl acetate and lead citrate.

### Results

In the healthy control disc (Fig. 1) and in those pathological samples with comparatively normal macroscopic features (Fig. 2) the superficial tissue consisted of dense bundles of collagen fibers packed in a scanty ground sub-

stance and running in a parallel arrangement to the surface. They were intermingled with rare elongated fibrocytes. The surfaces of these discs were covered by a regular layer (0.1–1 µm thick) of amorphous material. This superficial layer was highly basophilic after toluidine blue staining for light microscopy and at the ultrastructural level it appeared as a very electron-dense material. It showed a lamellar or granular

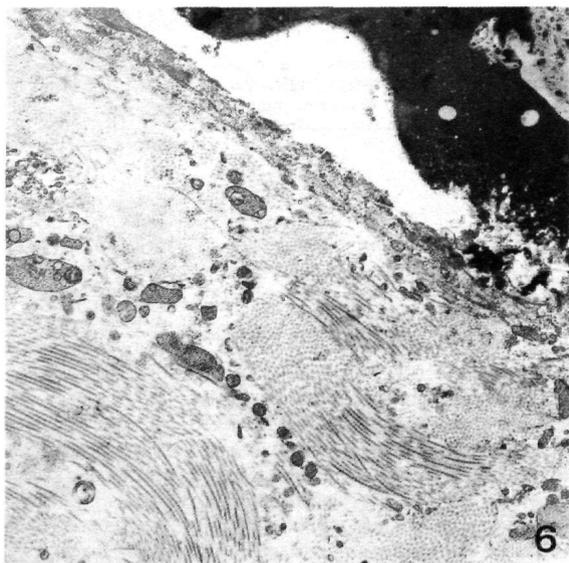
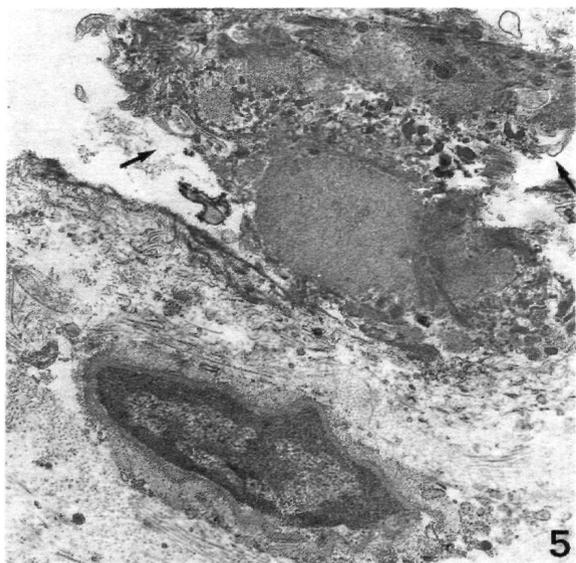
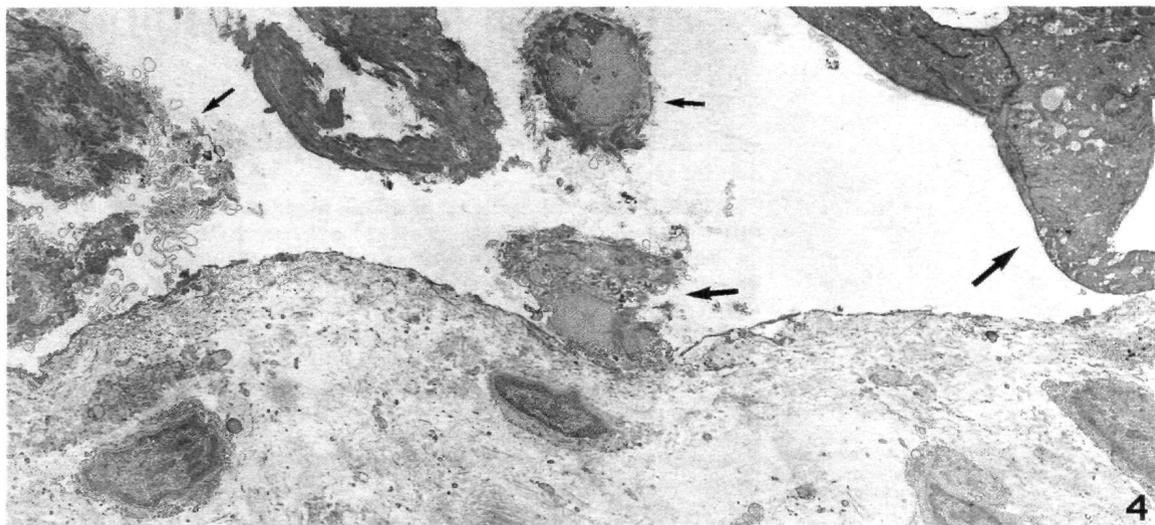


Fig. 4. Electron micrograph of a damaged disc. The abundant connective tissue matrix of the superficial discal tissue contains scanty fibers and some cells. At the surface of the disc, large irregular aggregates of heterogeneous material (arrows) are visible. Note the detachment of some aggregates from the discal surface. ( $\times 3150$ )

Fig. 5. Higher magnification of part of Fig. 4. A fibroblast-like cell in the superficial discal tissue. One aggregate of dense, amorphous material with cellular debris, vesicles and membranes (arrow) is evident at the surface of the disc. ( $\times 8100$ )

Fig. 6. Electron micrograph of the loose connective tissue of a damaged disc, with cellular debris, scanty collagenous fibrils and electron-dense amorphous material covering the discal surface. ( $\times 8100$ )

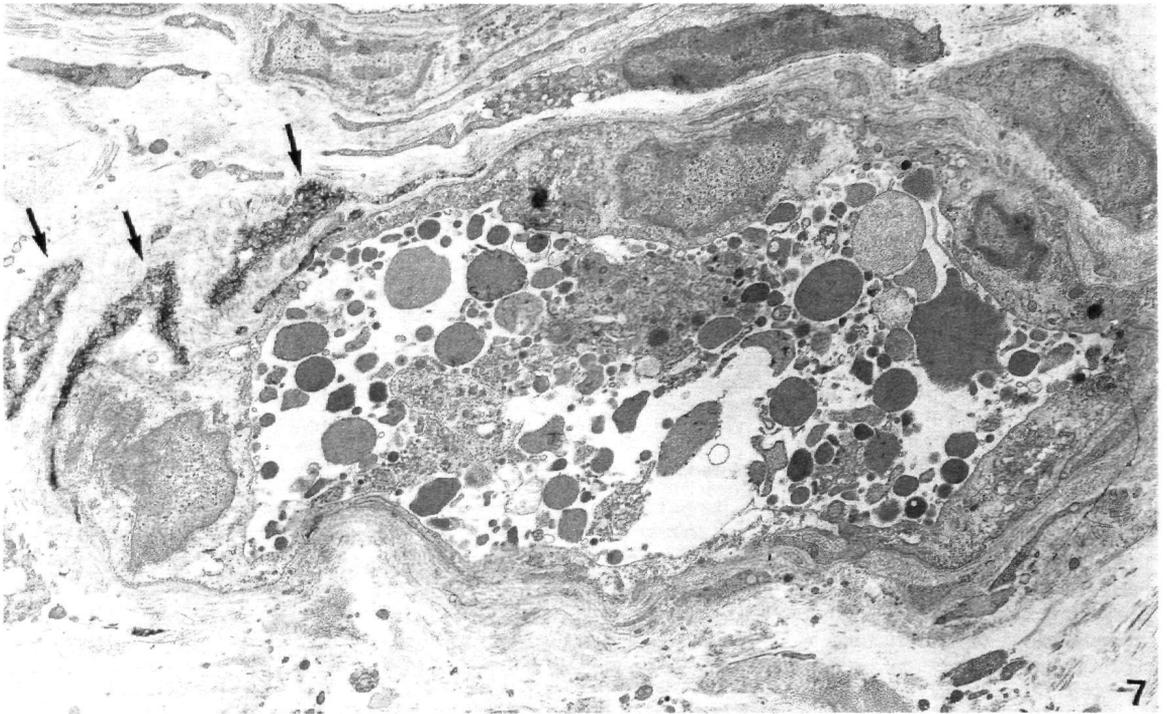


Fig. 7. Electron micrograph of a blood vessel in the inner part of a severely damaged disc. The vessel lumen is occluded by thrombi. Beyond the vessel, foci of mineral aggregates can be detected (arrows). ( $\times 5300$ )

pattern or was devoid of any apparent structure (Figs. 1, 2). In deeper regions some of the pathological discs presented a less compact fibrous structure, with bundles of irregularly arranged collagen fibers.

In the discs presenting a remarkable degree of modification in their macroscopic shape, with irregular or undulated surfaces, the bundles of collagen fibers were irregularly and loosely arranged and were frequently interwoven in the superficial regions as in the deeper parts. Numerous cells with different shape were present and irregularly distributed among the superficial fibers. Fibers and cells were incorporated into a loose ground substance that was more abundant in pathological discs than in the control disc (Figs. 3, 4). The discal surfaces were irregularly coated by a basophilic layer. In some areas this appeared as a regular lining (1–3  $\mu\text{m}$  thick); in other parts it was gathered in dense and irregular aggregates (Figs. 3–4) and in yet other portions it was completely lacking. On ultrastructural examination some superficial cells presented cytoplasm with a prominent rough endoplasmic reticulum, while other cells (Fig. 5) showed cytoplasm

containing residues of cisternae and vacuoles. Cellular debris, vesicles, granules and isolated collagen fibrils were frequently present in the most superficial regions of the fibrous tissue of the pathological discs (Figs. 5–6). Vesicles, granules, filaments, fragments of membranes and probably cellular debris were also present in the amorphous electron-dense material of the superficial coating. In some areas the surface layer was in close connection with the discal tissue, while in other parts it seemed detached from it (Figs. 4–6).

In four severely damaged discs the inner part was vascularized and in two discs the blood vessels showed thickened walls while their lumina were frequently occluded by thrombi. Foci of mineral precipitates were occasionally present (Fig. 7).

#### Discussion

Our observations demonstrate that the superficial tissue of the articular disc can undergo significant structural modifications under pathological conditions similar to those described for the inner parts of the disc (8, 10, 11). Nevertheless, these modifications ap-

pear in discs with particularly altered macroscopic features clinically corresponding to severe TMJ dysfunction syndrome. In slightly damaged discs, which had not been subjected to serious functional anomalies, the superficial discal layer maintained structural normality if compared to the already disorganized deep fibrous tissue.

In pathological discs an increase in the number of cells with abundant cytoplasm demonstrates the persisting capacity of the discal tissue to produce new matrix for reparative reconstruction. The appearance of degenerating cells and cellular debris represents morphological indications of a degenerative process in the discal tissue.

The basophilic staining and the ultrastructural features confirm the possible proteoglycan nature of the surface lamina in the healthy disc or in the slightly damaged discs.

A synovial origin has been proposed for the articular surface lamina in healthy discs under normal conditions (14, 15). The increase in thickness and the irregular distribution and composition of the surface covering layer in some damaged discs suggest that this layer is involved in the pathogenesis of

the discal modifications. In particular, vesicles, filaments and granules present in the large aggregates at the surface of severely damaged discs resemble the cellular debris of the adjoining superficial discal tissue. They may be the result of a degenerative process impairing the metabolism of all discal tissues, as demonstrated by the presence of foci of mineral aggregates and other pathological phenomena. Such a degenerative process could result in the accumulation of cellular remnants and their detachment into the joint spaces.

Our observations suggest that the disc can also be involved in the accumulation of material at the articular surface of the condyle or the temporal fossa. This event may be responsible for a successive impairment in the lubrication of the joint and the failure of articular movements.

In summary, we draw two main conclusions concerning the morpho-functional correlations in the TMJ: 1) The preservation of the structural integrity is guaranteed by the articular movements and by the correct displacement of the loading forces applied to the articular surfaces. 2) Structural modifications initially occur in the deep regions of the disc because these parts mainly experience the variations in intensity of mechanical stimuli.

This study demonstrates that the superficial discal tissue and the covering layer play a fundamental role in maintenance of the nonadherence condition of the articular surfaces. The simultaneous development of structural modifications in both components of the disc demonstrates their close morphological and functional correlation. Moreover, the discal articular surface seems to have the capaci-

ty to make functional compensations when tissue alterations have already occurred in the deep regions. Structural alterations in the disc surface occurring in serious and chronic functional TMJ diseases may be responsible for the successive deformation or adherence and immobilization of the disc in some cases of joint locking.

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