INNERVATION OF THE TEMPOROMANDIBULAR JOINT
AN EXPERIMENTAL ANIMAL MODEL USING
AUSTRALIAN MERINO SHEEP

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ABSTRACT

The present study provides a detailed account of the anatomical and neurohistological structure of the temporomandibular joint (TMJ) in foetal and adult Australian Merino sheep. The purpose is to describe the innervation of the joint and to determine the possible roles of both afferent receptor structures and neuropeptides in the pathophysiology of experimentally induced osteoarthritis.

A total of 33 adult and 7 fetal Australian Merino sheep were used for this investigation. The surgical procedure developed by Professor Goss and his Japanese colleagues was used to induce osteoarthritis. Gold chloride and glyoxylic acid as well as single, double, and triple labelling immunocytochemical techniques were used to localise nerves and their peptide distribution in normal, experimental and in late gestation fetal TMJ. Transmission electron microscopy was employed to examine the ultrastructural details of the morphology of nerves supplying the normal adult TMJ. Scanning electron microscopy was applied to study the surface topography of normal and arthritic joints. In addition, laser scanning confocal microscopy was used whenever more specific details of neural structures were required. Nerve fibre densities were quantified using image analysis of immunofluorescent staining and tested statistically using a general linear model.

Except for some differences in the shape of the mandibular condyle and glenoid fossa, the macroscopic and microscopic appearance of the sheep TMJ was generally similar to that described for other mammals. The mandibular condyle separated from the glenoid fossa of the temporal bone by an articular disc. The peripheral part of the disc merged with the capsule, thus separating upper and lower joint compartments. The condylar head and temporal surface of the joint consisted of a relatively acellular fibrous articular surface and underlying cartilage.
The auriculotemporal, deep temporal, and masseteric branches of the mandibular division of the trigeminal nerve contributed branches to the TMJ. Nerve fibres supplying the joint covered almost the entire range of diameters from large myelinated (A alpha-), through small myelinated (A delta-) to small unmyelinated (C-) fibres. The majority of fibres were myelinated with diameters <6 μm. The capsule, synovial membrane and peripheral part of the disc contained nerve fibres immunoreactive (IR) to antisera for PGP 9.5, and neuropeptides SP and CGRP. Noradrenergic fibres were also demonstrated mainly in the capsule. In addition, Ruffini, paciniform-type and Golgi organ nerve endings were located in the capsule with the highest density of nerve endings occurring at the site of attachment of the disc to the capsule. The highest density of autonomic fibres was in the anterior capsule and the highest density of sensory fibres was in the synovium and capsule of the anterior region of the TMJ in normal adult sheep.

The fetal sheep TMJ at 140 days gestation age (full term=157) was not fully developed. The superior joint compartment was present but the inferior joint cavity was incomplete and confined to a narrow region anteriorly, near the capsule/disc junction, but over most of the mandibular condyle the disc was continuous with the cellular fibrous tissue on the superior surface of the condyle. Some small clefts indicated the location of the developing inferior joint cavity.

The study showed that the pattern of neuropeptide-immunoreactive fibre distribution in the fetal sheep TMJ disc differed from that of the adult TMJ disc. At 140 days gestation the entire disc was innervated by SP-, CGRP- and PGP 9.5-IR fibres, while in adult sheep the disc was innervated only in the peripheral part at the site of attachment to the capsule. This supported the view that the TMJ disc is innervated during fetal development but at later ages these nerves degenerate and persist only in the peripheral disc. Furthermore, CGRP- and SP- immunoreactivity suggested that these nerve fibres
in fetal sheep TMJ disc were sensory, for nociception and perhaps mechanoreception, and might also have had a role in regulation of vascular supply to joint tissues through the release of SP and CGRP in joint tissues. The lack of receptor endings, other than free nerve endings in the late gestation of fetal sheep used in this study might have been a reflection of anatomical and perhaps functional immaturity of the TMJ, as reflected in the gross and microscopic appearance of the disc, the inferior joint compartment and articular surface of the condyle at this stage. Thus the present findings support the view that weight bearing postnataally might influence the distribution of receptor endings in joints and that mechanical stimuli might be necessary for the maturation of receptor endings postnataally.

The arthritic TMJ joints were characterised by abnormalities mainly in condylar surfaces. Macroscopically, the articulating surface of the temporal fossa appeared normal. Erosions and outgrowths were observed on all condylar surfaces, but these deformities were different from one animal to another, even between the left and right joints of the same animal. Peripheral osteophyte formation, fibrosis and sub-cortical cysts were obvious. The osteoarthritic changes were commonly seen in the anterior and lateral regions of the condyle. Microscopically, fibrosis of bone marrow and trabecular remodelling were obvious. Subcortical cysts were also the common feature in all condylar surfaces. No disc perforation was present in all joints examined. However the peripheral parts of the lateral and anterior parts of the discs were either folded or sharply thinned.

The qualitative assessment of the effect of experimentally-induced degenerative disease on the TMJ in the present study suggested that the density of nerve fibres immunoreactive to antisera for PGP 9.5, CGRP and SP was less in the arthritic TMJ capsule than in the normal capsule. In addition, there seemed to be fewer nerve fibres in parts of the sheep TMJ that were most affected by the degenerative changes. Nevertheless, the quantitative data showed no statistically significant effect (P>0.01) of
induced osteoarthritis on the percentage surface areas or number of PGP 9.5- or CGRP-IR nerve fibres in the capsule.

The results of this investigation show that while the development of TMJ in human and sheep fetuses follows a similar sequence, there are differences in the timing of neural and morphological development. In addition, this study suggests that while inflammatory arthritis has a marked influence on the density of sensory and autonomic nerve fibres in synovium, the experimentally induced non-inflammatory osteoarthritis in the sheep TMJ broadly maintains a nerve supply similar to normal joints.
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