

# Comparison of different methods of temporomandibular joint disc reconstruction – An animal model

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## Abstract

The optimum method of temporomandibular joint (TMJ) reconstruction has not been defined despite numerous surgical treatments and several well controlled clinical trials. Animal models offer an experimental method allowing direct comparison of standardized surgical techniques. Advanced osteoarthritis was induced bilaterally in 12 mature merino sheep. Three months later unilateral surgical reconstruction was performed. Four sheep had discectomy alone, four discectomy with fresh TMJ disc grafts, and four discectomy with fresh auricular grafts. All three surgical methods resulted in some reversal and repair of the osteoarthritic process, with the best result being from the auricular graft, next discectomy alone, next the disc graft, with the untreated osteoarthritic joint showing the most advanced pathosis. This study supports the role of surgical reconstruction in advanced degenerative disease of the temporomandibular joint, in particular, auricular graft reconstruction.

**Key words:** Temporomandibular joint, surgery, animal models.

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## Introduction

The disc is an essential component of the temporomandibular joint (TMJ). In the normal joint it has the following function: it spreads the intra-articular load, stabilizes the joints during translation and decreases the wear of the articular surface. When the disc is displaced, malformed or worn then this is a key feature of the pathologic processes of internal derangement and/or osteoarthritis.<sup>1,2</sup> In severe cases of intra-articular pathosis, if appropriate non-surgical treatment has been tried and failed then surgical reconstruction is indicated.<sup>3,4</sup>

The 'best' method of surgical reconstruction remains undefined. Some advocate removal of the disc without replacement,<sup>5</sup> others disc removal with replacement by a range of autogenous grafts such as skin or cartilage,<sup>6</sup> and others discectomy with replacement with a foreign material such as silicone.<sup>7</sup> All have received initially good reports although in the long term joint implants do not do as well as biological procedures.<sup>8</sup> In recent years various groups have developed detailed criteria by which clinical trials should be measured and how they should be performed.<sup>4,9</sup>

Common elements in these studies are that for optimum results clinical trials should be prospective, with strictly standardized operating protocols on age, sex and the clinical stage of the disease being standardized. If two techniques are being used then there should be randomization of treatment. Large clinical groups are required with long follow-up. These criteria are easily stated but in clinical practice, difficult to apply.

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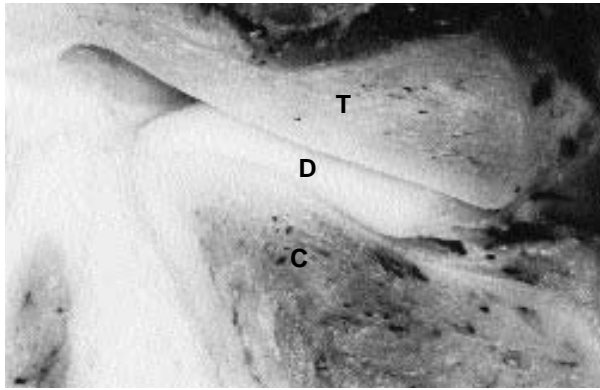


Fig. 1. - Right temporomandibular joint - normal. The biconcave disc is between the temporal and condylar surfaces. The surfaces are smooth and congruent.

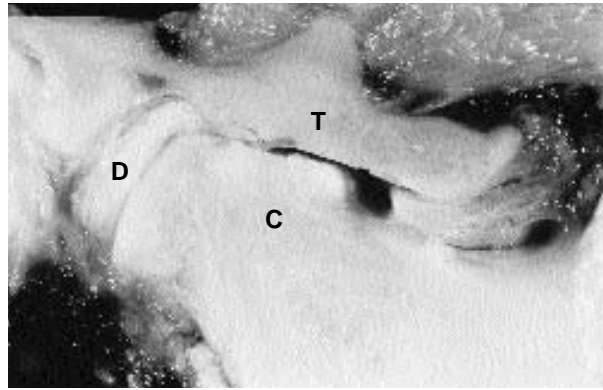


Fig. 2. - Right temporomandibular joint - 6 months osteoarthritis. The disc is central perforated with osteophyte formation peripherally and centrally on the condyle. The temporal surface is irregular.

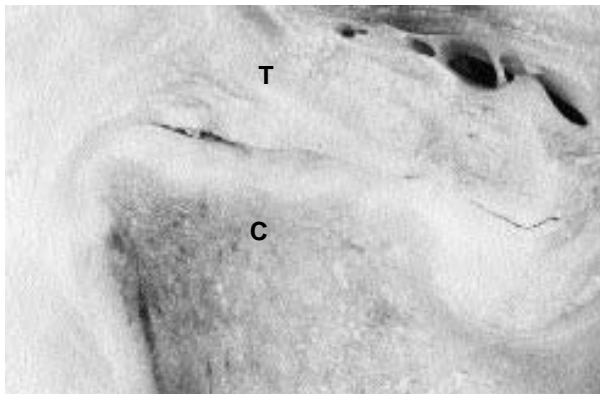


Fig. 3. - Right temporomandibular joint - 3 months discectomy. The condylar surface is flattened and covered by a thickened articular layer. The temporal surface is thickened and irregular but congruent with the condyle.

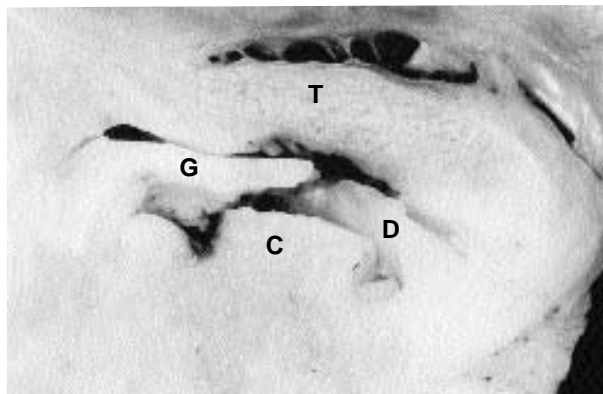


Fig. 4. - Right temporomandibular joint - 3 months fresh disc graft. The fresh disc graft is attached posteriorly but not anteriorly. There is marked remodelling of the condylar and temporal surfaces with uneven and non-congruent surfaces.

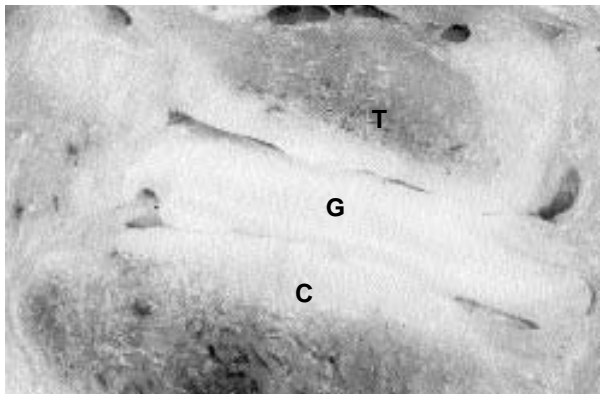


Fig. 5. - Right temporomandibular joint - 3 months auricular graft. The auricular graft is in the position of the disc and is attached to the peripheral tissues. The condylar and temporal articular surfaces are thickened but congruent with the disc replacement.

T = Temporal bone  
 D = Disc  
 C = Condyle  
 G = Graft

An alternative method is to develop and use animal models where conditions can be standardized. The common laboratory animals (rats and rabbits) have been used, as have primate models. A common problem with these studies is that the animal model has not been fully characterized, and that the surgical reconstruction is performed on normal and not pathologic joints. The Japan-

Australia Temporomandibular Joint Disorders Research Group is an international collaboration between Oral and Maxillofacial Surgeons at Aichi-Gakuin University in Nagoya, Japan, Gifu University, Gifu, Japan, and The University of Adelaide, Adelaide, Australia. This Group has developed the sheep as a model for temporomandibular joint research.<sup>10</sup> The results of some 36 investigations completed in the last five years have recently been published as a Monograph.<sup>11</sup> The key feature of this work is that the animal model is well characterized anatomically, physiologically, biomechanically and pathologically. Standardized methods of inducing different degrees of internal derangement and osteoarthritis have been developed. Thus the model allows for comparison between different methods of surgical treatment for disease.

This paper presents a comparison of three different methods of reconstruction of the disc in pre-conditioned osteoarthrotic joints using the sheep model.

## Method

Twelve mature merino sheep had bilateral surgical procedures to induce osteoarthritis. The sheep were anaesthetized with intravenous thiopental, intubated, and the temporomandibular joints exposed under standardized surgical conditions. Mild damage was caused to the superficial condylar surface with a scalpel blade and periosteal elevator. The abraded articular surface was irrigated and the wounds repaired in layers. The sheep were returned to normal field conditions chewing grass within one week of the surgical procedure.

Three months after the initial surgery, unilateral reconstruction of one joint was performed. Four sheep had discectomy alone, four sheep had discectomy followed by replacement with a fresh TMJ disc graft, and four sheep had discectomy followed by an auricular graft. The contralateral joint in each animal was left undisturbed.

The surgery was performed under similar conditions to that at which the osteoarthritis was induced. Discectomy was performed by removal of all residual disc tissue. Replacement with fresh TMJ joint disc material involved harvesting the disc from another animal which was being sacrificed following orthopaedic experiments. The excised disc was sutured to the peripheral disc tissue with interrupted resorbable sutures. The period from graft harvest to placement was less than 30 minutes. The auricular graft was performed by obtaining a cartilage graft from the ipsilateral sheep's ear. Following discectomy the auricular graft was sutured in place using interrupted resorbable sutures. The donor graft site was repaired by suturing.

At six months following the initial surgery and three months following the reconstruction, the sheep were sacrificed by a lethal overdose of barbiturates. The TMJ was removed *en bloc* with a band saw and fixed in formalin. The TMJ was radiographed from the lateral and anterior-posterior aspects. The blocks were then decalcified and vertically sectioned into anterior, lateral, and medial specimens. These were photographed prior to histologic processing.

Four TMJs from two unoperated sheep were similarly processed as controls. The experiment was performed in accordance with the ethical guidelines of The University of Adelaide, and the care of the animals was directed by a veterinary surgeon.

## Results

The normal macroscopic appearance of the sheep temporomandibular joint is shown in Fig. 1.

The six month osteoarthrotic joints showing the typical features of advanced osteoarthritis is shown in Fig. 2.

The discectomy alone joints are shown in Fig. 3.

The discectomy with fresh temporomandibular joint disc graft is shown in Fig. 4.

The auricular graft replacement is shown in Fig. 5.

Generally there was a similar appearance in all specimens within each group.

## Discussion

This study shows that all three surgical interventions resulted in some reversal and repair of the osteoarthrotic process of the sheep temporomandibular joint. Generally the auricular graft resulted in the greatest degree of improvement, discectomy alone next, the fresh disc graft the least; but all showed greater evidence of repair than the untreated osteoarthrotic control. The advantage of animal models are that they allow comparison of standardized pathosis treated with standardized surgical techniques. This allows for accurate and reproducible demonstration of the biologic response to treatment.

A number of different species of animals have been tested for temporomandibular joint studies. Rats and rabbits are commonly used but there are marked dissimilarities in size, anatomy and function of the TMJ from humans. There is greater similarity with the TMJ of primates, but there are serious issues concerning the cost and ethics of primate experimentation.

The sheep has the advantages of having a TMJ which is similar in size, thus allowing similar surgical techniques; it is a robust animal and it has high ethical acceptability.<sup>10</sup> There are differences in masticatory physiology but these have been well characterized. Sheep spend a considerable part of their life cropping grass and then subsequently ruminating. Thus there is considerable masticatory activity which allows for condensation of the length of experiments.<sup>11</sup>

The current experiment could be criticized on the grounds of small sample size, unilateral surgical procedures and ethics. The small size is in part dictated by cost, but as homogeneous results were achieved in the groups, the use of four joints is appropriate. Current studies by the Japan-Australia Research Group on unilateral condylectomy show that there is an alteration in biomechanics of the jaw. This is confirmed by preliminary intra-articular pressure experiments. However performing unilateral reconstruction on diseased joints allows comparison between experimental and control in the same animal. Ethically there is wide acceptance of the sheep as an acceptable animal model. It is noted that the degenerative process is not inflamed and thus not osteoarthritic, hence the use of the term osteoarthritis. The involved animals return rapidly to normal masticatory function.

Good clinical results have been presented over a long term with discectomy alone.<sup>5</sup> Philosophically

however it is a mutilative procedure and thus there is a tendency for surgeons to prefer some type of disc reconstruction. Good results have been presented for discectomy with auricular grafts replacement.<sup>6,12</sup> The use of fresh disc grafts has not been reported in clinical trials. Similar types of graft transfer have however been reported for the knee. Given that the use of TMJ disc grafts replaces diseased tissue with normal tissues of the same type and function, then this concept needs to be further pursued. Clinically the use of alloplastic materials has resulted in failure in the medium to long term.<sup>8,13,14</sup> Similar results have been demonstrated in the sheep using silicone,<sup>15</sup> and guided tissue regeneration membranes. The alloplastic materials migrate and fragment inducing a destructive foreign body reaction.

It would be overly simplistic to directly extrapolate these research findings to the clinical situation. It does however provide insight into the biological processes which occur with these grafts. It also confirms the surgical clinical view that surgical reconstruction of joints does have a place in the management of advanced disease.

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