# A possible role of synovial fluid in bone healing

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## Abstract

**Background**
The aim of the study was to study the rate of intra-articular fracture healing in baboons. It is postulated that this could correlate with fracture healing in the human model of the scaphoid, as this fracture healing takes place in an intra-articular environment.

**Methods**
Five baboons were used. Segments of iliac crest were divided along the cancellous zone and fixed together by means of cerclage wire with the cancellous surfaces facing each other. The conjoined blocks of bone were sutured into the joint capsule of the suprapatellar pouch of the animal from which they were obtained.
Control specimens were fixed submuscularly to the outer cortex of the iliac crest. Specimens were harvested at two, three and four weeks. After decalcification, samples were examined histologically.

**Results**
All specimens were found to be viable. A firm union was noted at two weeks, a greater union at three weeks, and a substantial union at four weeks. Some of the specimens had a covering of synovial membrane, due to the fact that the specimen was sutured into the joint lining. It appeared to have no effect on bone survival or the rate of union.

**Conclusion**
The results suggest that synovial fluid may nourish bone and promote union. This is in contradiction to the theory that synovial fluid may hamper bone healing, specifically in the scaphoid model in humans.

**Key words:** synovial fluid, bone healing, intra-articular fractures

## Introduction

It is widely believed that the presence of a layer of synovial fluid at the fracture line may inhibit the healing of intra-articular fractures. On the other hand, osteochondral loose bodies do survive within synovial fluid and grow to a considerable size.[1]

*Research suggests that synovial fluid might support bony union*

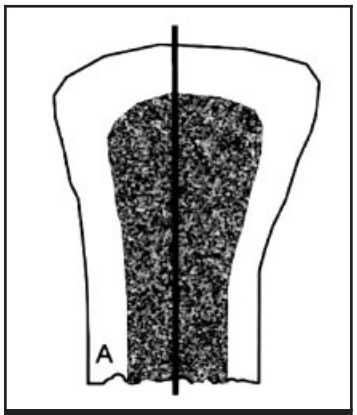


*Figure 1a. Segment of iliac crest*

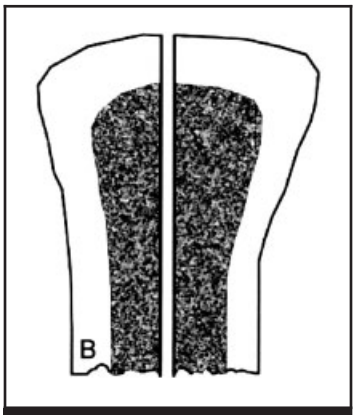


*Figure 1b. Crest split into two along the cancellous zone*

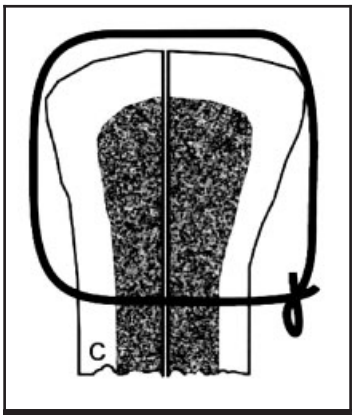


*Figure 1c. Fragments wired together with cancellous bone facing each other*

In 1989 Mass and Tuel showed that tenocytes could survive and proliferate in a medium consisting entirely of synovial fluid.[2] In their work on intra-articular tendon healing, Lundborg and Rank placed two segments of tendon sutured together within rabbit knee joints.[3] They demonstrated that tenocytes could survive in synovial fluid, retaining the capacity to heal. The results of the above research suggested that synovial fluid might support bony union.

This work describes the use of a primate model to study the role of synovial fluid in bone healing.

## Materials and methods

Five baboons (Papio papio), each weighing about 40 kg, were selected for the study. We chose primates for this research because of their evolutionary and genetic proximity to man (Animal Ethics Screening Committee Certificate No. 98.95.5). Segments of iliac crest measuring 5 cm × 1 cm were harvested and divided into five fragments of 1 cm.

Samples were divided into two along the central cancellous zone. The cortical fragments were held together with wire so that the cancellous surfaces faced each other (*Figure 1 a, b, c*). A control specimen was attached submuscularly to the outer cortex of the iliac crest and the wound was closed in layers. Two of the bony units were inserted into the suprapatellar pouch of each knee. A total of five units, each consisting of two pieces of bone wired together with the cancellous surfaces facing each other, were used in each baboon. A Dacron stitch through the wire loop anchored each to the joint capsule to prevent mechanical locking.

All the baboons recovered uneventfully and by the next day were moving normally. No haematomata were noted. Skin wounds healed well. Specimens were harvested from two baboons at two weeks, from one at three weeks, and from the remaining two, at four weeks after insertion. The partial synovial covering, when present, and the wire loops were removed and the specimens fixed in 10% buffered formalin before being prepared for histological examination.

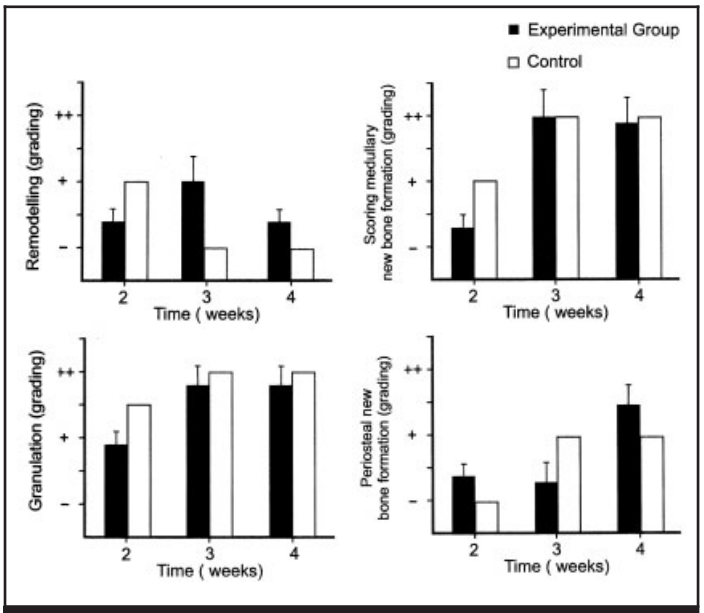


*Figure 2. There was no statistically significant difference in the criteria considered between the control and synovial groups, keeping in mind the relatively small series.*

*We chose primates for this research because of their evolutionary and genetic proximity to man*

Each specimen was evaluated in terms of five parameters: the presence of bone necrosis; medullary cavity new bone formation; periosteal new bone formation; degree of remodelling; and the extent and nature of granulation tissue formation.

The extent of these parameters was determined semi-quantitatively (*Figure 2*). The criteria for new bone formation were the presence of trabeculae of osteoid or mineralising osteoid with osteoblastic rimming.

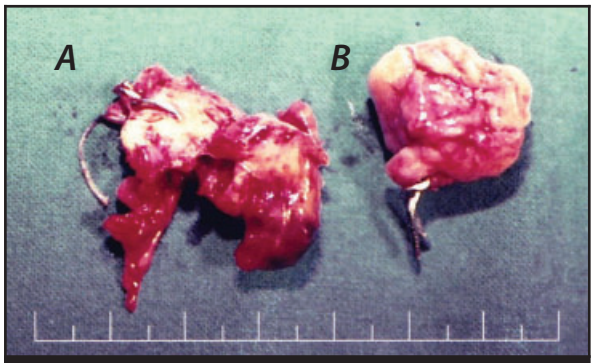


*Figure 3. Specimen A was the control removed from the iliac crest. It was tightly bound to the cortex by gritty calcified fibrous tissue. Specimen B was taken from the knee four weeks after insertion. Some of its surface was covered by synovial membrane.*

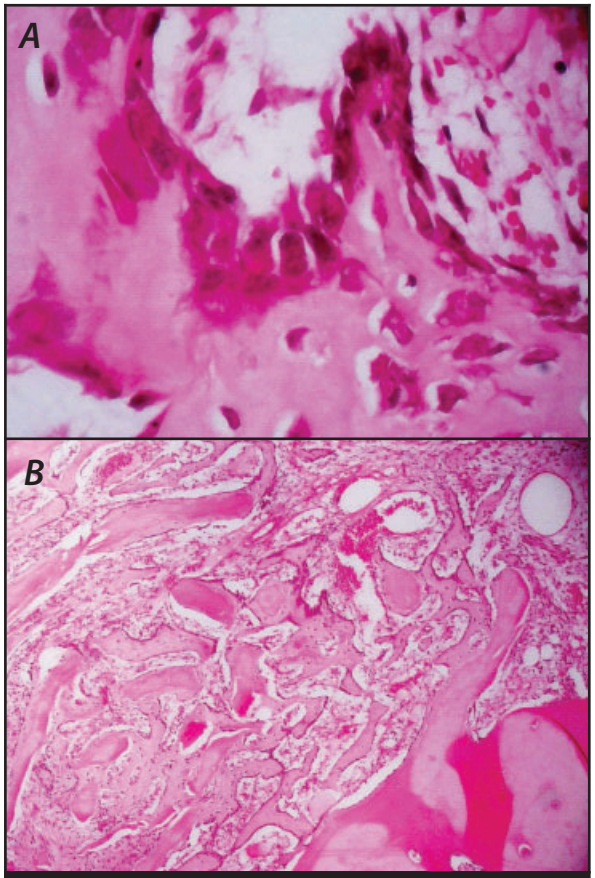


*Figure 4. The sections were decalcified and stained with haematoxylin and eosin. Slide A shows prominent osteoclastic activity in existing cancellous bone indicating remodelling. Slide B shows prominent new bone formation.*

*Union was unaffected by the presence or absence of synovial membrane*

Remodelling was assessed on the presence of new bone formation and osteoclastic resorption. Osteoclastic activity was noted in most specimens and was part of the remodelling process. New bone was observed both in the periosteum and subperiosteum where there are most uncommitted mesenchymal cells and better nutrition. Osteoblasts are thought to develop from either uncommitted stem cells or native osteocytes. The age of granulation tissue was assessed on the degree of extracellular myxoid matrix (younger granulation tissue) versus the extent of dense relatively acellular collagen deposition (older granulation tissue).

There was no evidence of samples having drawn a physical blood supply from synovium.

Histological sections were reviewed by the pathologist and senior colleagues in the Micropathology Department.

## Results

The control specimens were found to be tightly attached to the outer cortex of the ilium by what appeared to be very gritty calcified callus. Ten specimens were removed after two weeks of insertion and five after three weeks.

Specimens removed from the supra-patellar pouch at two and three weeks had no synovial covering. Some of the ten specimens removed at four weeks had a covering of synovial membrane that varied from 0% to 50% (*Figure 3*).

The fact that the specimens were anchored into the synovial pouch enhanced the tendency for synovial encapsulation. There was a moderate effusion in three knees and a small haemarthrosis in one. All specimens were totally viable and showed no evidence of bone necrosis. The degree of bony union varied according to the time at which the specimens were harvested, with obvious bony union present at two weeks and greater union at three weeks.

There was substantial union at four weeks (*Figure 4*). Comparing the control specimens with the intra-articular specimens, we found no difference in the rate of bony union. Union was unaffected by the presence or absence of synovial membrane.

## Discussion

The fact that intra-articular loose bodies may grow to considerable size and remain viable suggests that synovial fluid has a nourishing role according to Duthie and Bentley.[1] The work of Bird and Sweet suggests that in the normal knee synovial fluid plays an important role in nutrition of the meniscus and intra-articular ligaments.[4] Mass and Tuel showed that tenocytes could survive and proliferate in synovial fluid alone.[2] When Lundborg and Rank (1978) placed tendon segments into rabbit knee joints they also demonstrated the continued ability of tenocytes to survive within synovial fluid.[3] These results suggested that synovial fluid might support bony union.

The scaphoid is entirely intra-articular and more often than not poorly vascularised. A bone graft, which has no source of nutrients except for synovial fluid, is used to treat non-union of the scaphoid. This procedure carries a success rate of 90%.[5-8]

The high rate of union may be due to the nourishing role of synovial fluid. (In a consecutive personal series of 95 cases of scaphoid non-union and a success rate of 95% treated between 1980 and 2004, there was an absence of synovial membrane covering or proliferation at the fracture site – Biddulph, unpublished work).

## Conclusion

Our results show that excellent repair, remodelling, new bone formation and bony union occur in specimens of bone joined together and placed within a synovial joint. These data support the theory that synovial fluid may play a role in bony union.

Synovial covering influenced neither the rate of healing nor specimen survival. In the clinical context, the treatment of non-union of scaphoid fractures provides a good example of this phenomenon.

*The content of this article is the sole work of the authors, and no benefit of any form has been received or will be received from any commercial party.*

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