•Rapid Bone Modeling and Remodeling in a Mandibular Segmental Defect Using a Novel Distraction Osteogenesis Instrument: Results from a Pilot Study Using the Genesis® Device

INTRODUCTION: Large mandibular bone defects, resulting from trauma, extractions, or tumor, must be filled with bone of high quality before teeth can be effectively restored. Autografts pose issues of donor site morbidity, and allo- or xenografts may have complications of disease transmission or transplant rejection. Local regeneration of sufficient autogenous bone stock to allow for solid implantation would be a useful addition to the oral surgeon’s armamentarium in these cases. In this pilot study, we examine the effects of a simple distraction instrument in a controlled canine mandibular segmental defect model, at one week, three months, and six months post-distraction.

METHODS: Under local IACUC approval, 3 adult castrated male Beagles were anesthetized and prepared for sterile surgery (Day 0). A mucoperiosteal flap incision, incorporating right premolars (PM) 2 through 4 was created, and a unilateral partial-thickness mandibular mucoperiosteal flap incision, incorporating right premolars (PM) 2 and 4 (Fig.2), and the two components were assembled without applying a distraction force. The mechanism of action of this device, with its lack of positive mechanical adhesion to the underlying bone suggests some role for the cellular response to local cytokines such as TGF and VEGF (previously shown to reach their peak concentrations in fracture healing). The apparent rapid transitions, first from woven to plexiform (more commonly seen in ununited or fracture), and then to secondarily remodeled bone in the defect is remarkable given the rather slow apposition rates measured in these sections.

DISCUSSION: These data represent the results from three dogs only, with no device-only, non-distraction controls, and should be considered only as a preliminary proof-of-concept. Nevertheless, the device shows promise, and the results raise some intriguing questions regarding modeling and remodeling at this site, the types of bone tissue to be expected in distraction osteogenesis, and the role of the fracture clot in mechanically-induced modeling and remodeling. The gap has significant fill with secondary compact lamellar bone (Fig.9), with occasional superficial remnants of the plexiform bone (Fig.10). The middle, granular layer is not seen. In all sections, on both sides, there were multiple double-labeled osteons (Fig.11), even though interlabel intervals ranged from 81-132d. Apposition rates ranged from 0.18-0.30 microns/day.

REFERENCES:

Fig.1: Osteotomy cut (red) and mucoperiosteal flap incision (blue).

On Day 119, the flap was opened and several 4mm deep, 1-2mm diameter holes drilled dorsoventrally into the mandible at the site of the defect, into the crest of the residual ridge. The titanium distraction plate was applied directly to the bone surface, with the only connection between the plate and the bone being the blood clot. The anchor component, which allows for normal mastication, was adhered with dental cement to the crowns of PM1,2, and 4 (Fig.2), and the two components were assembled without applying a distraction force. The flap was closed about the distraction plate in a routine fashion. Animals were allowed unrestricted dog-run activity, and were maintained on a soft diet until distraction was completed.

Fig.2: Distraction plate (left), and full device (right)

On Day 126, distraction was initiated, at a rate of 1mm/day for 7 days, at which time a second tetracycline label was given. On Day 139, distraction was stopped, and the anchor component was cut between the plate and the bone being the blood clot. The gap has significant fill with secondary compact lamellar bone (Fig.9), with occasional superficial remnants of the plexiform bone (Fig.10). The middle, granular layer is not seen. In all sections, on both sides, there were multiple double-labeled osteons (Fig.11), even though interlabel intervals ranged from 81-132d. Apposition rates ranged from 0.18-0.30 microns/day.