Reduced scarring with using an “Ultrafast” laser: a wound healing study in mice

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INTRODUCTION:
Surgery requires the creation of wounds which heal through a repair process consisting of three overlapping phases: inflammation, proliferation, and remodeling. About 3% of surgical patients have problems with wound repair, especially hyperplastic scarring, which has functional and cosmetic implications. This is especially a problem in surgeries around tendons and joints.

Though lasers have emerged as a method of creating incisions with less scarring, contemporary surgical lasers impair the proliferative phase of healing due to thermally-induced cell damage and death adjacent to the wound. This deleterious effect delays healing and actually results in a hyperactive proliferative phase, causing larger wounds.

We developed a new “ultrafast” laser which eliminates heat transfer in tissue and thus reduces the thermal damage, associated with the hyperactive proliferative phase of wound repair. Here, we compared the wound healing from the use of the novel ultrafast laser over a fine surgical scalpel. In addition, we examined the expression of various markers of wound repair, including β-Catenin and p-Smad2, two key signaling molecules, which are known to regulate wound size and scarring.

METHODS:
Ten CD1 mice received six 4 mm linear incisions each (3 laser and 3 scalpel) and ten received four 4 mm diameter circular excisions each (2 laser and 2 scalpel), for a total of 100 wounds. Wounds were harvested at 3, 6, 9, 14, and 21 days postwounding and paraffin embedded sections were stained with Masson’s trichrome to compare wound size, Aniline Blue to compare collagen deposition, and with immunohistochemical stains for KI-67 antigen (a proliferation marker) and β-Catenin to determine if the expression of key pathways regulating wound size was different.

RESULTS:

1. Ultrafast laser wounds are smaller and have more collagen than scalped induced wounds during the proliferative phase.

Trichrome staining of scalpel induced wound showed 32% to 267% increase in wound size compare to laser wounds. This difference started from days 3 postwounding and maximize at day 9 (P<0.05).

2. Collagen deposition is faster in presently healing tissue in Ultrafast laser wounds compare to mechanical wounds.

3. Higher proliferation in presently healing tissue of scalpel induced wounds compare to laser wound.

CONCLUSIONS:
Measurements indicate that wounds created by the ultrafast laser are smaller than those created using a scalpel (p<0.05). In addition, collagen deposition in laser wounds occurs faster, suggesting the presence of mature fibroblasts in these wounds earlier than in scalpel induced (mechanical) wounds. These observations may suggest that mechanical wounds experience an extended proliferative phase which not only increases the number of cells in the presently healing dermis but also delays their differentiation into mature fibroblasts, the functional components of a healed dermis in normal skin.

KI-67 staining supported our hypothesis as there was 2-3 times more KI-67 positive cells in mechanical wounds compared to ultrafast laser wounds.

β-Catenin, a key molecule in Wnt pathway, has been shown to regulate wound size (Cheon et al. 2006), during healing as well as a role for TGF-β signalling in expression of β-Catenin. As such, we examined the β-Catenin and p-Smad2 expression pattern and verified a higher expression of β-Catenin and p-Smad2 in scalpel induced wounds, suggesting hyperactivation of the Wnt/β-Catenin pathway secondary to hyperactivation of TGF-B pathway in mechanical wounds compared to ultrafast laser wounds.

This is the first report of the use of an ultrafast laser for a surgical application. The reduced scarring (smaller wound size) associated with this laser is likely related to the reduced extracellular matrix damage.

This laser could be used to reduce scar formation for surgery around tendons and joints, as well as in revision surgery for hyperplastic scars.

REFERENCE;