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TITLE: “Laser Applications on Orthopaedic Bone Repair”

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The views, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy or decision unless so designated by other documentation.
The goal of this project is to improve the treatment of bone defect by leveraging a rat cortical bone allograft model and Er:YAG laser currently used in the dental field. To achieve this goal we will test the hypothesis that: 1) segmental bone defects treated with Er:YAG laser irradiation will form significantly more and stronger cortical bone allograft incorporation; and 2) segmental bone defects treated with cortical bone allograft pre-conditioned by Er:YAG laser will form significantly more and stronger cortical bone allograft incorporation. The project is currently in progress and definitive results await further analysis. However, post-operative observations and body weight gain indicated there were no complications such as allergic reactions, abscesses or infections. Body weight gain in the laser-treated animals was similar to that in non-laser treated animals during the healing period. These results showed a successful feasibility of the Er:YAG laser system for the cortical bone allograft model.
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INTRODUCTION

It has been reported that more than 30,000 American service members have been wounded in the wars in Iraq and Afghanistan during the last six years. The majority of service members who are wounded in action sustain musculoskeletal injuries such as the orthopedic-related trauma involving the upper and lower extremities present with a significant bone defect. Bone allografts have become an accepted technology to replace bone loss. However, major complications reported for grafting procedures are infection, bone graft fracture, non-union at the graft-host interface, and, rarely, massive allograft resorption. Recent advances in technology have led to a development of novel approaches for use of lasers in hard tissue surgeries in the dental field. The laser that show the most promise for hard tissue surgery is the erbium:YAG (Er:YAG) laser. Recent reports indicates Er:YAG laser provides; (1) advantageous bone surface for bone tissue repair; (2) bactericidal effect; (3) applications for both soft and hard tissue. However, it has not been shown whether Er:YAG laser has a positive effect on orthopedic bone repair. The goal of this project is to improve the treatment of bone defect by leveraging a rat cortical bone allograft model and Er:YAG laser currently used in the dental field. We hypothesis that: 1) allograft bed treated with Er:YAG laser irradiation will lead to more and stronger cortical bone allograft incorporation; and 2) segmental bone defects treated with cortical bone allograft pre-conditioned by Er:YAG laser will lead to more and stronger cortical bone allograft incorporation. The project is currently in progress and definitive results await further analysis. However, post-operative observations and body weight gain indicated there were no complications such as allergic reactions, abscesses or infections. Body weight gain in the laser-treated animals was similar to that in non-laser treated animals during the healing period. These results showed a successful feasibility of the Er:YAG laser system for the cortical bone allograft model. Samples are currently under investigation for micro CT analysis and mechanical testing.
The following is a summary of the work completed to the present time based on the project’s accepted Statement of Work. Comments by PI follow below.

Statement of Work

Task 1: Determine the effect of Er:YAG laser on allograft bed.

1a. Preparation for the animal study - completed
   Obtain animal use approvals and order the supplies.

1b. Preparation of the allografts - completed
   Obtain cortical bone grafts from the donor rats (n=26; 2 grafts/animal) prior to the surgery. Allografts will be sterilized with 70% ethanol and then fresh frozen at -80°C until use.

1c. Perform surgery – harvest after 4 & 8 week post-surgery - completed
   Perform surgery; create segmental defect (n=78) and utilize cortical bone allograft grafts (n=52) prepared above (1b). Some animals (group 2 & 7) will undergo laser irradiation during the surgery. Four and 8 weeks post-surgery, for mechanical testing, the dissected bones will be wrapped in saline soaked gauze and frozen at -20°C. For undecalcified histology, the dissected bones will be fixed in 10% neutral buffered formalin.

1d. Analyze the samples - in progress
   Analyze the samples by µCT, mechanical test and histology.

Task 2: Determine the effect of Er:YAG laser on allograft.

2a. Preparation for the animal study - completed
   Obtain animal use approvals and order the supplies.

2b. Preparation of the allografts - completed
Obtain cortical bone grafts from the donor rats (n=26; 2 grafts/animal) prior to the surgery. Allografts will be sterilized with 70% ethanol and then fresh frozen at -80°C until use. Some allografts (for group 3, 4, 8, and 9) will undergo laser irradiation prior to the surgery.

2c. Perform surgery - harvest after 4 & 8 week post-surgery - completed

Perform surgery; create segmental defect (n=52) and utilize cortical bone allograft grafts (n=52) prepared above (2b). Some animals (group 4 & 9) will undergo laser irradiation during the surgery. Four and 8 weeks post-surgery, for mechanical testing, the dissected bones will be wrapped in saline soaked gauze and frozen at -20°C. For undecalcified histology, the dissected bones will be fixed in 10% neutral buffered formalin.

2d. Analyze the samples - in progress

Analyze the samples by µCT, mechanical test and histology.

Comments:

The project is currently in progress and definitive results await further analysis. However, post-operative observations and body weight gain indicated there were no complications such as allergic reactions, abscesses or infections. Body weight gain in the laser-treated animals was similar to that in non-laser treated animals during the healing period. These results showed a successful feasibility of the Er:YAG laser system for the cortical bone allograft model. Contact X ray images obtained during the healing period indicate similar or larger callus in laser-treated groups compared to non-treated groups. However, these qualitative observations are done in two-dimensional, projected image while subsequent micro CT analysis will provide better understanding in three-dimensions. Moreover, mechanical testing is the primary endpoint for the project which will be performed after non-destructive-X ray analysis. Project is extended for additional 6 months to complete the sample analysis and manuscript preparation.
KEY RESEARCH ACCOMPLISHMENTS

- Completed all animal surgeries.
- No adverse effect or complication by use of Er:YAG laser in cortical allograft model.

REPORTABLE OUTCOMES

The investigators are currently awaiting results of ongoing analysis from the project. Following personnel received research training based on animal procedures in this research project which includes introduction and training for Er:YAG laser.

- Vbenosawemwinghaye Orhue, M.D. – Postdoctoral fellow
- David F. GomezGil, D.D.S., M.S. – Ph.D. candidate
- Siddhesh R. Angle, Ph.D. – Ph.D. candidate
- David G. Karwo, B.S. – Research assistant
- Julie E. Brown, B.S. – Research assistant
CONCLUSION

- There was no adverse effect or complication by use of Er:YAG laser in cortical allograft model.
- Project is extended for additional 6 months to complete the sample analysis and manuscript preparation.
APPENDICIES

1. Memorandum for the Record – Approval of extension (3/16/2012)
AMENDMENT OF SOLICITATION/MODIFICATION OF CONTRACT

1. The purpose of this modification is to extend the period of performance, without additional funding, from 1 September 2010-31 March 2012 to 1 September 2010-30 September 2012 (research ending on 31 August 2012).

2. The final technical report originally scheduled for 31 March 2012 will now be submitted as an annual technical progress report. The final technical report will now be due on 30 September 2012.

3. All other terms and conditions of the award remain unchanged.

EXCEPTION TO SF 30
APPROVED BY OIRM 11-84
STANDARD FORM 30 (Rev. 10-83)
Prescribed by GSA
FAR (48 CFR) 53.243
SECTION 00010 - SOLICITATION CONTRACT FORM

CLIN 0001

The CLIN extended description has changed from Period of Performance: 1 September 2010-31 March 2012 (research ends 29 February 2012) Peer Reviewed Orthopaedic Research Program (PRORP)-Hypothesis Development Award to Period of Performance: 1 September 2010-30 September 2012 (research ends 31 August 2012) Peer Reviewed Orthopaedic Research Program (PRORP)-Hypothesis Development Award.

DELIVERIES AND PERFORMANCE

The following Delivery Schedule item for CLIN 0001 has been changed from:

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(End of Summary of Changes)