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THE EFFECTS OF LASER BEAMS WITH DIFFERENT WAVE LENGTHS ON LEFT ANTERIOR DESCENDING CORONARY ARTERY

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ABSTRACT

Introduction: Lasers have found a wide field of use after. Theodore Maiman developed first operating laser in 1960. Health sector is one of these fields. Applications in cardiovascular surgery field are yet new and promising applications.
Material and Method: The aim was to investigate the usability of lasers in different wavelength (980 nm and 1470 nm fiber laser) in coronary artery surgery. The effects of 980 nm and 1470 nm fiber lasers on left anterior descending coronary artery (LAD) were evaluated. Sheep LAD was used in the experiments as their dimensions and thickness is close to human LAD and easy reachability. The hearts of the sheep cut only for consumption, not for experiment, were bought from the cutting center and brought to the laboratory in half an hour to be examined.
Result: Using 980 nm fiber laser, application was made with 6.8 W power, low pressure and constant contact. Overpenetration was provided through full-thickness penetration in LAD. Using 1470 nm fiber laser, application was made with 11.4 W power, low pressure and constant contact. Full-thickness penetration was not acquired in LAD and overpenetration couldn't be provided.
Discussion: Coronary artery surgery is one of the most important application fields of cardiovascular surgery. In our study evaluating the usability of 980 nm and 1470 nm fiber lasers in coronary artery surgery, we detected that 980 nm fiber laser had a higher effect on LAD intima layer compared to 1470 nm fiber laser and was more compatible with LAD tissue. Endoscopic application of coronary artery surgery by using laser can provide many advantages to the patients such as fast wound recovery, less pain and shortened discharge duration. But more comprehensive studies using more data are required in this field.

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INTRODUCTION

Laser applications based on the electron transfers between atom or molecule energy levels and oscilatory light photons are used in many fields today from cutting operations in industry to distance measurement in architecture and spectroscopic diagnosis methods to lighting sector. Health sector is one of the areas where laser applications are studied mostly.

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First successful applications of lasers in health sector started on retina in ophtalmology. Ophtalmology applications are among the disciplines in which lasers are still most commonly used today. In addition to prostate diseases in urology, laser applications are used in many fields such as gynecology, dermatology and brain surgery. Applications are available for destroying the tumors using the heating effect of lasers in oncological surgery and studies are being continued on this subject (Rahmathulla *et al*., 2014). Laser applications are also used for treatment in varicosis surgery field of cardiovascular surgery (Uncu *et al*., 2015). They are also used in carotid

artery surgery and atheroma plaques intervention. Transmyocardial revascular iz ation method in which channels were formed with laser applications on myocardium was also tried. With this method defined by Mirohseini *et al*. (1993), remodeling was asserted to be triggered in hearts with widespread schemia and scar and decreased pumping function. But the success in varicosis treatment could not be provided in other similar applications in cardiovascular surgery and efficient routine application couldn't be started. Applying 980 nm and 1470 nm fiber lasers on LAD in our study, our aim was to evaluate the usage area of these lasers with different wavelengths in coronary artery surgery.

MATERIAL AND METHOD

980 nm and 1470 nm fiber lasers were used in the study. Investigating the effects of these lasers with different wavelength on LAD, their usability on coronary artery surgery was evaluated. Sheep LAD was used as their dimensions and thickness is close to human LAD and easy reachability. The hearts of the sheep cut only for consumption, not for experiment, were bought from the cutting center and brought to the laboratory in half an hour to be examined. Parts to be used in experiments were provided by Elif Kombine Et Tesisleri in Tuzla İstanbul. In 30 minutes after the cutting, the sheep heart was brought to Kandilli Bio-Engineering Laboratories to release the LAD. After releasing LAD with 15 no bistoury (Figure 1), tubulary artery was made single layer strip with coronary scissors. It was located on experiment platform with intima layer on the top (Figure 2). Experiment assembly was arranged as; 1- Laser source, 2- Optic matcher, 3- Fiberoptic cable, 4- Experiment material, 5- High power detector. A damp environment was provided with serum physiological solution to prevent the drying of LAD on the platform. LAD tissues macroscopically examined after laser application were prepared in 4x4 mm cross-sections. The tissues prepared were fixed with paraformaldehyde solution for 24 hours. Then the dehydration stage was started. In this stage, tissues were exposed to alcohol solutions with a gradually increasing concentration and xylene which is a strong solvent. Finally the tissues were washed with melted paraffin and water was replaced by paraffin and dry paraffin blocks were formed by the tissues. Then 6 micrometer cross-sections were formed from the tissues using microtome so that thin cross-sections can be taken from fixed tissues. The cross-sections were placed on slides after water bathing at 45 degrees. As the aim was to detect morphological changes occurring due to laser, the cross-sections were stained with Hematoxylin-Eosin frequently used in similar applications. While staining the cell nucleus to purple, hematoxylin stains cell cytoplasm to pink. The tissues were covered with lamellas using varnish at the end of staining. The tissues were examined under the microscope after the staining was over and the cross-sections were documented. The cross-sections examined were viewed using both white light and polarized filter. Polarized filter provides a chance for more sensitive examination of tissue changes.

RESULT

Using 980 nm fiber laser, application was made with 6.8 W power, low pressure and constant contact. Over penetration was provided through full-thickness penetration in LAD (Figure 3,4). Using 1470 nm fiber laser, application was made with 11.4 W power, low pressure and constant contact. Full-thickness penetration was not acquired in LAD and over penetration couldn't be provided (Figure 5). 980 nm fiber laser had a higher effect on LAD intima layer compared to 1470 nm fiber laser and was more compatible with LAD tissue.

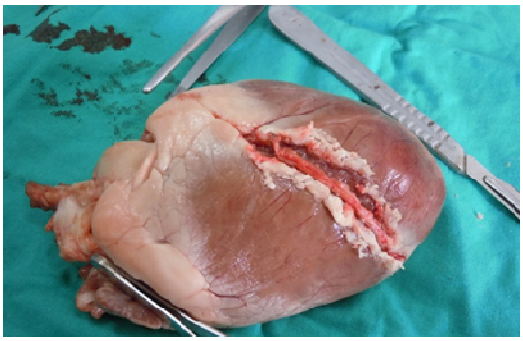

Figure 1. Dissection of LAD from surrounding tissues with bistoury

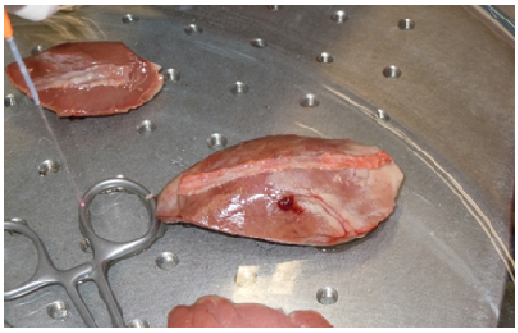

Figure 2. LAD prepared for experiment

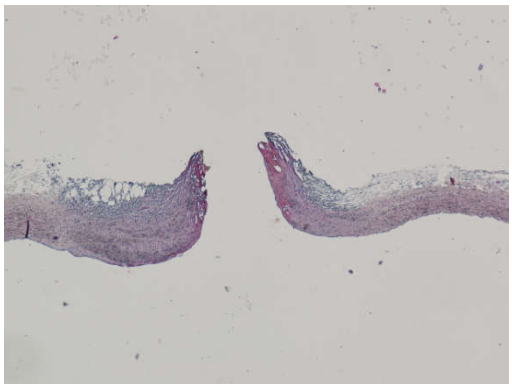

Figure 3. Full-thickness penetration and overpenetration in 4x enlargement

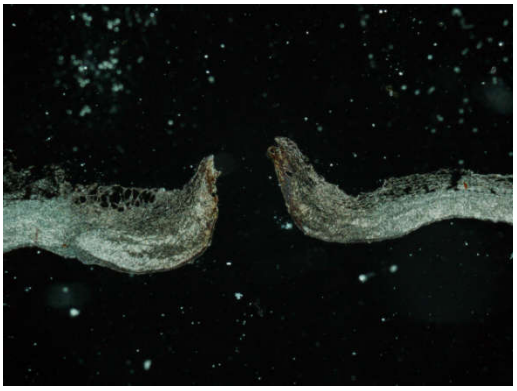

Figure 4. Polarized form of the cross-section in Figure 3

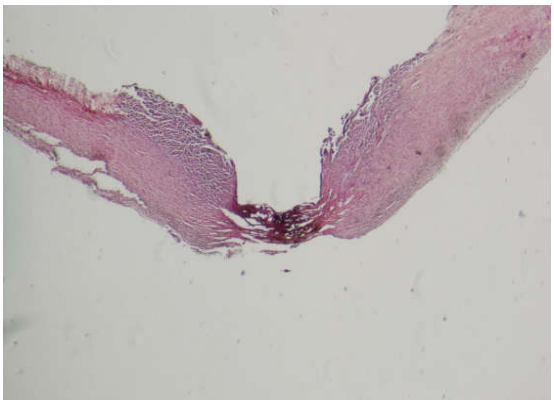

Figure 5. Full-thickness penetration and overpenetration were not observed in 4x enlargement

DISCUSSION

Laser is an acronym for "Light amplification by stimulate emission of radiation". Theodore Maiman discovered the first operating laser made from ruby crystal in Hughes Research Laboratory on May 16, 1960 (Maiman, 1960). The interaction between the target tissue and the laser used is important during the medical use of laser beams. Future effects on the tissue are based on factors such as 1- Wavelength of the laser applied, 2- Power of the laser applied, 3 - Application duration, 4 - Application way (continues, pulsatile), 5 - Optical and absorption characteristics of the tissue (Gulsoy et al., 2006). The popularity of laser has increased with the successful corneal applications in medical area, especially ophthalmology (Bragge *et al*., 2011). Corneal applications also have an importance for cardiovascular surgery. Because cornea has a high protein-collagen content similarly to vascular endothelial structure. Also both of these have a transparent white color. Corneal applications made until today have aimed only the evaporate the cornea without harming the neighboring tissues. This was the effect we aimed to form on coronary artery in our study. Causing minimal damage on neighboring tissues, our aim was to form a clear bordered cut only in the application area. Laser use has gained attention also in brain surgery field. Microvascular anastomosis technique which is an interesting unstitched microvascular anastomosis was defined by Jain in 1980 for the treatment of cerebral diseases (Jain, 1983). A branch of superficial temporal artery was anastomosed on middle cerebral artery cortical branch with this method. Jain used YAG laser for this. Although this method causing minimal damage on endothelium layer created great reactions at first, it was abandoned later due to the high complication rate. Then Neblett *et al* combined this method with the conventional stitching method and reported good results (Neblett *et al.,* 1986). Laser usage applications in cardiovascular surgery were primarily made on the ateron plates on veins. Ateron plates in coronary veins were successfully cleaned with laser angioplasty but early restenosis rates were reported high after smooth muscle cell proliferation (Chu *et al*., 1999). Jain *et al* were successful in end to side anastomosis of carotid arteries using YAG laser. They reported that anastomosis made with laser was a faster, less traumatic and less individual-dependent technique which didn't leave any foreign matters in anastomosis line (Jain, 2005). Transmyoc ardial revascularization (TMR) technique opening channels with laser beam on myocardium was also applied in cardiovascular surgery. Mostly using YAG laser, this was especially tried on patient with low cardiac pumping function (Hughes *et al*., 2000). Krabatsch *et al* results of 100 TMR applied patients in Berlin Heart Institute between 1994 and 1995 were published. 9 of 100 patients died in perioperative period. Postmortem autopsy was applied in eight of these patients. According to the examinations, there was only one patient with an open channel. Fibrin and blood product remains were generally detected in the channels (Krabatsch *et al*., 1996). It was reported that TMR occurred with thrombus and fibrin formation in the channels in early period and triggered inflammation and neovascularization mechanisms (Burkhoff *et al*., 1999). Today, lasers are most commonly and effectively used in varicosis treatment in cardiovascular surgery (Uncu *et al*., 2015). In this study, investigating the effects of laser beams with different wavelengths on LAD, our aim was to evaluate the usability of lasers in coronary artery surgery. Overpenetration and full-thickness penetration were provided in 980 nm. 980 nm fiber laser had a higher effect on LAD intima layer compared to 1470 nm fiber laser and was more compatible with the tissue. Endoscopic application of coronary artery surgery by using laser can provide many advantages to the patients such as less pain, fast wound recovery and shortened hospitalization duration. But comprehensive studies using more data are required in this field.

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