Biophotonics
Professor Basudev Lahiri
Department of Electronics & Electrical Communication Engineering
Indian Institute of Technology, Kharagpur
Lecture 43
Laser Tissue Welding and Tissue Regeneration

Welcome back, we are discussing tissue engineering with light and today's topic is laser tissue welding and tissue regeneration. So, thus far we have mostly discussed about how laser light can be used to destroy something a part of a tissue and thereby remove it either it is arteries, or some part of your skin. It is, previous one was basically a destructive process. Now, we want to discuss about a soldering process or a tissue regeneration process.

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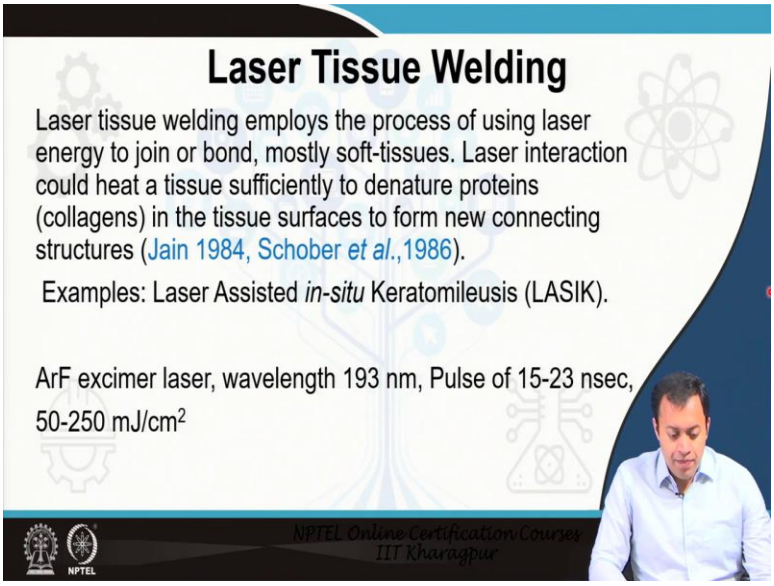

So, what exactly is laser tissue welding? In the very first class I discussed a bit about it, it is like you are fusing two metal plates, you are soldering two metal plates. But here it is the similar technique more or less, you are using laser energy to join mostly soft tissues. The jury's still out when it comes to hard tissues whether you can add to bones, a bone that has broken down whether you can connect them together, the jury's still out and we are not getting exact amount of success, but soft tissues such as skin or blood vessels or certain nerve endings can actually be reconnected using laser light.

So, laser interaction heats the tissue sufficiently to denature the proteins the collagens you know by this time what collagens are connective proteins. And these collagens they form new

connecting structures we utilize some kind of laser tissue shielding in LASIK surgery I have a specific topic dedicated in next class on laser application in ophthalmology, eye surgery.

And I will be discussing a bit of LASIK laser assisted in situ keratomileusis, you will be going to detail but just for the time being this is ophthalmology surgery, eye surgery where you we use argon fluoride excimer laser, which acts in the infrared and this is its nanosecond and very, very top most laser that we utilize and this is a fascinating topic.

I am keeping LASIK for the last few classes because it will require my full energy and my full intention for me to make you understand. Vision is always my favorite topic and when anything related to vision I would like to so. But overall understanding this topic that laser tissue welding is connection of two tissues, we heat up the collagens, the collagens uncoil, the protein uncoil, the uncoiled proteins after some time after the temperature or after the energy has been dissipated, after the heat has been dissipated recoil but this time the recoiling is in a different way. And this different way fuses the overall tissue that is the overall idea.

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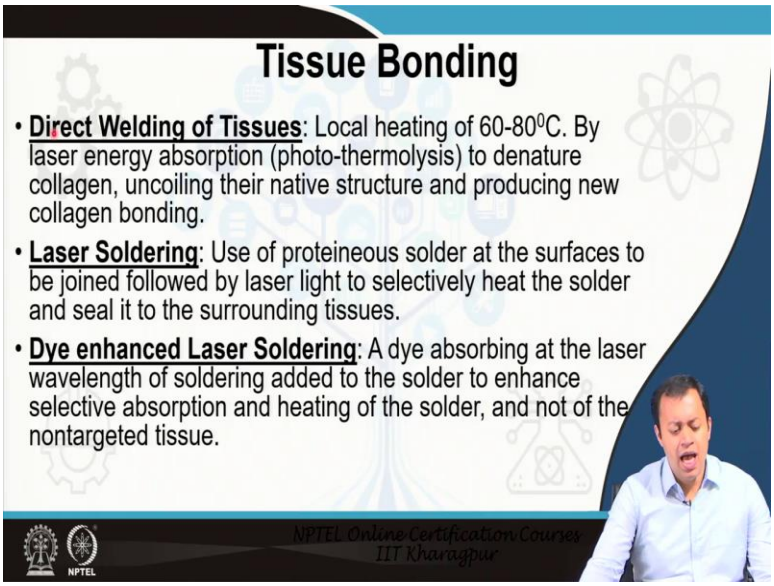

So, how do we do it, we three major methods, either we go for direct welding of tissue, local hitting 60 to 80 degree Celsius, photo thermolysis to denature collagen, uncoiling as I just said uncoiling their native structure and producing new collagen bond. So, two collagens, two separate tissues they are in a colloidal manner, you heat this up and this opens up, you heat this up and this opens up and they come together if they are close enough.

And after upon removal of laser light they can recoil back by this time they have connected. So, this is direct welding of tissues. There are of course, other methods such as laser soldering, where you use a proteinous solder so there are two different tissues, you connect something in between, so you make something in between a connective material in between.

So, this is a tissue, this is a tissue you put some kind of a tape or a connector between them. You heat this tape rather than the tissues. You heat this solder up and this solder heats, melts, fuses, and connects these two separate things together. Here, the soldering you might have seen we put some kind of a tape in between two plates and then heat the tape and the tape melts and connect the two metal plates.

This is this has been going on for a pretty long time. So, it is not a, it is not a new thing. We are just applying the same concepts here in biophotonics. Remember biophotonics borrows unashamedly concepts from several different engineering fields, mechanical engineers, will laughing at me. So, you selectively heat the solder and the solder seals the surrounding tissue, here instead of heating the tissue, you heat the solder, that is laser soldiering.

Then obviously, there is die enhanced laser soldering, a dye absorbing at the laser wavelength of soldering added to the solder to enhance selective absorption and heating of the solder and not of the non target tissue. So, a selective portion of the solder selective portion of the solder is being heated not the entire solder certain section of the solder that is getting heated.

So, basically you add selectivity you do not want the entire portion of two different tissue to bond together, you want some amount of flexibility, some amount to bond, some amount not to bond. So, you cover it with some kind of a packaging material solder which contains dyes, dyes are dispersed in them, dyes are disperse in them, these dyes absorbed a specific amount of laser.

So, wherever the dyes are dispersed, that will connect, that will solder wherever the dyes are not present that will not solder. So, it is giving you flexibility depending on what kind of surgical procedure you need to do, it is giving you that flexibility.

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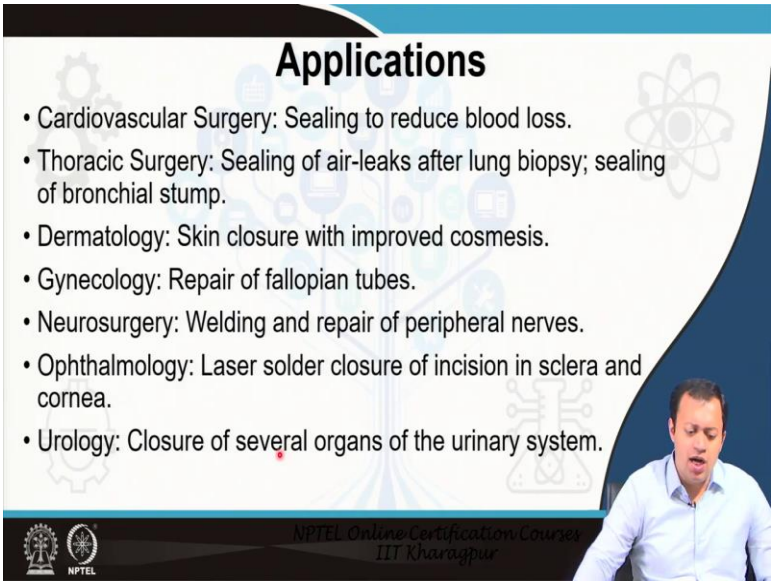

So, where do you need to use them? Well, several cardiovascular surgeries you seal blood capillaries, blood vessels, remember we can had now have the technology to go inside, very, very small vesicles. So, like you saw in that angioplasty concept, you need to go very small ventricle, a small vein or a small capillary that needs to seal so that it reduces blood loss.

Internal bleeding is a nightmare for any surgeon after post operation we always need to check whether there is internal bleeding, there is thoracic surgery sealing of air leaks after lung biopsy. Once you have done lung biopsy, once you have taken that BAL liquid, I think Bronchoalveolar lavage that is being called you insert something and there is a fluid present in our lungs that is being taken out to check for well Coronavirus, infection or any kind of thoracic infection.

And that can many times inserting some kind of a tube inside your lung and then taking it out damages the lung resulting in air leaks and you do not want a leak in your lung obviously. So, that that needs to be sealed. Dermatology, obviously skin closure with improved cosmesis. Gynecology, fallopian tubes get damaged or congenitally several women suffer from congenital defect in fallopian tubes thereby preventing them from getting pregnant.

So, if there is some kind of a tissue growth in the fallopian tube, you can use laser-based surgery to first cut it and then join that to part. So that can be done, that is possible. Obviously, neurosurgery welding and repairing of peripheral nerves. This will take us in a fantastic new area

of neuro photonics that is the last chapter, neurosurgery where how light is utilized to both change as well as repair the brain.

Ophthalmology, laser solder closer for incision in scaler and cornea I have, I am itching for teaching you this how, how laser can be used to correct your vision. And of course, urology, several organs of the urinary system need to be rectified by laser-based ceilings certain things will cause problem if you are, if you have air leakage or blood coming out or even urine is coming out from areas that are not meant to be coming, if you have urine forming inside your body rather than, rather than outside or outside the bladder inside your body. It can cause infection and that nobody wants that. So those things can be done using laser beam soldering.

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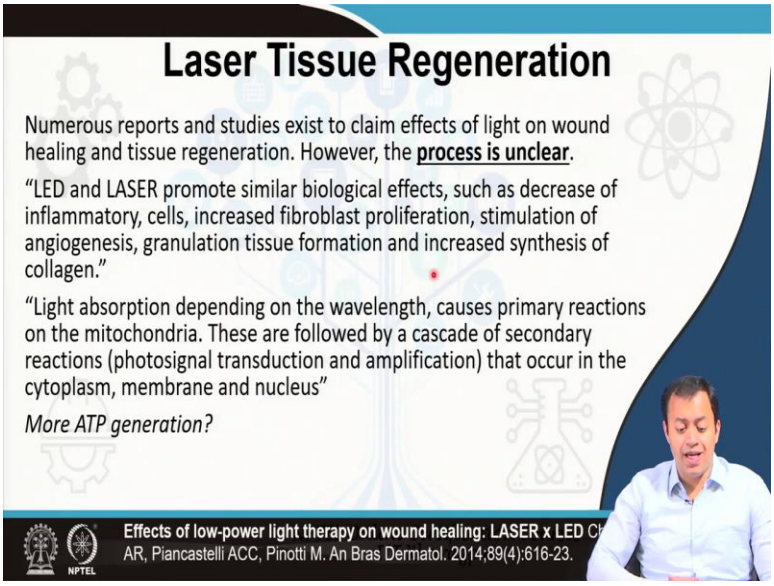

So, that is basically the process. Here, I will take you to the next topic and I am dreading because this will open up a whole new cane of worms, but I think all of you are sufficiently mature to understand this part of the topic and that is laser tissue regeneration. And as soon as I talk about tissue regeneration, well, this goes into the realm of quackery.

So, well we trade where angels dare. So, let us go on with it. Laser tissue regeneration, numerous reports and studies exist that shows or that claims that light has been utilized for wound healing and tissue regeneration. So, a light is falling on a specific part of a tissue and that tissue is growing or do you have a pain light is falling the pain is going out and there is a wound, light has fallen on it and the wound has healed.

Now, you immediately understand that how much potential this thing has and this is basically a minefield and this will immediately be hijacked by pseudo scientist and quackery and light therapy and whatnot. The process is unclear, there are claims and counterclaims on to it. However, we still do not know the exact science behind it, I was tempted actually to completely remove this part, but then I thought that I should be adding it because you would rather be informed of the pitfalls rather than be completely ignorant, there is only half a page in the Prasad's book.

So, I have to go through several other external sources to understand the effect of low power light therapy on wound healing laser and LEDs. And the idea here is laser and this is the, these two statements under the inverted commas are directly from the topic that they decreased the inflammatory cells increased fibroblasts, proliferation, etc. and increased synthesis of collagen.

Under, you know, inverted commas, this needs to be rigorously, mathematically, experimentally understood and tabulated and reproduced time and again, we still have not done that, we still have not reached that. The overall idea here is how does laser light causes the cell to grow? How does light make cell to grow? The idea, hypothesis, underlying the term hypothesis, states is that the light is being absorbed, a specific wavelength of light at a specific pulse rate, at a specific fluence is accepted by the mitochondria remember, mitochondria is the energy center this is the battery of the cell.

And these mitochondria, supposedly according to the hypothesis generates more ATPs, Adenosine Tri Phosphate these are the, I hope I pronounced it correctly. This is the currency, the energy currency, this is how the cell generates energy. So, mitochondria generate ATP and the laser light is somehow, again somehow is activating the mitochondria to generate more energy, more ATP molecules, generation of more ATP molecules is a growth factor, which is making the cell divide quickly or the cell to grow.

And thereby if you have a wound, where a cell has made a group of tissue or group of cells has been, injured or taken away or lesion is there or some kind of cut the surrounding cells upon activation by laser, their mitochondria producing more ATP, thereby the cells starts growing rapidly, thereby covering the wound. That is the overall hypothesis. I need to remind you I cannot repeat this open hypothesis, this has not been theoretically, experimentally, mathematically proved.

But before this get hijacked by pseudo scientists, you need to know that this is something that we are thinking that may happen. So, any times those light therapy this that happens, you need to approach this with a healthy amount of skepticism, a healthy amount of doubt in this particular regard is better and hence I have put the question mark here is, does it generate more ATP, we have not been able to experimentally determine it. We have not seen experimentally, there are certain claims but then there are certain counter claims as well. Just read through this paper and it has a list of claims and counterclaims.

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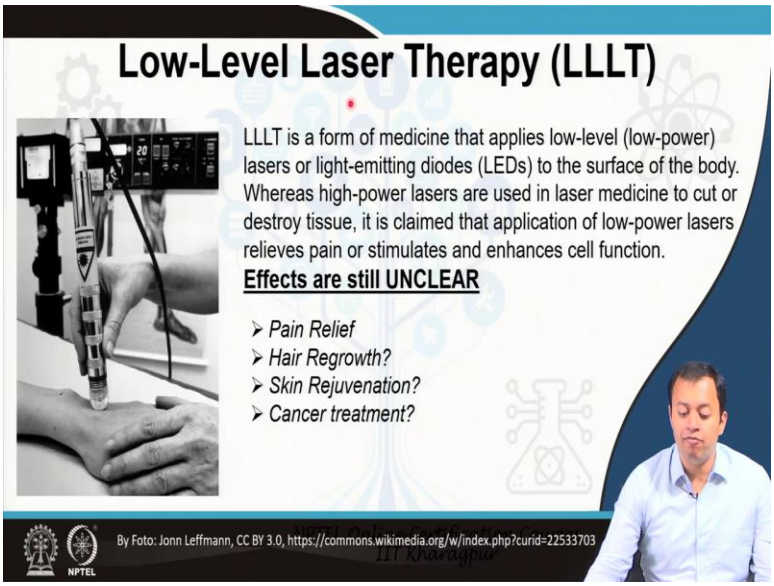

And that brings to low level laser therapy. This is becoming bi layer of a catch phrase of several quacks and several, scrupulous people who go through these kinds of business of fraud innocent people. So, you need to be very, very careful. The evidence for laser-based regeneration of cells are still sketchy, several papers have claimed, and they have come from very, very reputable source, Johns Hopkins University, University of Maryland I am an alumni from there along with several other various Boston University, they have shown us evidence that it does occur, but then there are several other universities, hospitals, institutes which has seen that there is no such effect.

So, I want you to be informed about the overall thing. So, low level laser therapy you will seek happening in several different institutes of repute as well. It is not that I am wholesale telling the

entire thing as buncombe, I am simply saying that it has the capacity, it has had the, it has a propensity to be hijacked by unscrupulous characters.

So, it is a form of medicine that applies low level laser or light emitting diode on the surface of the body are different places. Whereas, high power laser is used in to cut or destroy tissue as I said laser ablation. It is claimed that low power laser relieves pain or stimulates and enhance cell function, this is claimed, the we have not come to any conclusion yet.

So, any time any one of you want to go for laser therapy for rejuvenation, regrowth, these are the new terms, these are the good terms that are being sold as advertisement, I want you to go there with an healthy amount of skepticism, ask several questions, ask for evidence, instead of sending tons of money, instead of spending tons of money to this just be aware of the science that is available of what is known and most importantly, what is not known.

So, the effects are still unclear, I cannot repeat it enough that the effects are still unclear. Pain relief, I can understand say muscular pain, those of you who are more into fitness will know that muscle pain happens because of lactic acid formation into our muscle. So, maybe some kind of low-level heat is melting the lactic acid. So, some sort of that thing is acceptable, if you have an inflammation because it has something has hit your hand or hit some part of your body and it has inflamed.

So, we sometimes use heat or we sometimes use heat patch to reduce the inflammation or cold patch as well. We use ice on the inflammation place where it has swollen up. I can understand that some amount of small heat generation can help it but whenever you come to topics such as hair regrowth, this is a burgeoning topic, hair growth and skin rejuvenation and cancer treatment.

Remember the skin rejuvenation as I said that the upper layer is removed. It is still unclear that if your skin will grow new skin and it will look better and your skin cell will proliferate and you will look 20 years younger. So, be absolutely skeptical for these claims. Similarly, hair regrowth, we will put some amount of laser into your hair follicle that will stimulate the hair follicle and the hair will start growing.

Yeah, I do not think that is actually correct or even possible, you can destroy it, fine, but re-growing it may be maybe possible but I need to see the evidence. Thus far the evidence is scanty, evidence is quiet, quite low. And most importantly and this is the most tragic of all is this cancer

treatment. I told you light could be utilized in certain section for treatment of tumors. We had a whole topic discussion on PDT, photodynamic therapy, as well as direct to destroy tumors, but when it comes to laser rejuvenation of area where tumor has formed, the tumor has been removed and now you are sending laser to regrow that part that is simply tragic.

Because either your loved one is suffering from it or you are suffering from it and this is considered a last resort, and then it is getting hijacked by unproven science is actually quiet, quite sad. So, any of the time you go to any of these, I am not saying that low level laser therapy is wrong, I am saying that there are still a lot of work to be done in LLLT. To make it standardized at this present moment to the best of my knowledge, medical students correct me if I am wrong, I have seen LLLT being used in dentistry and I will be discussing a bit of dentistry as well.

But to the best of my knowledge LLLT is not that standardized, that popular, many medical Institute's, medical bodies are still skeptical of giving it a full-fledged license, but it exists. And it has come, it has been worked, it has been utilized in very reputed institutes by very reputed scientists. So, it is not that there is no evidence, there are certain evidence but it is still not enough to standardize it. Weather light can rejuvenate cells. There are there are studies and there have been there have been incidences where it has happened, it has actually happened.

I am not denying that part. I am simply staying, stating that there are counter studies as well and the full effect needs to be understood is it ATP formation from mitochondria that is causing the cell to degenerate, what, I mean we simply cannot say light has come and the cell has proliferated, we need to know why the cell has proliferated, we need to know the why part, the why part is still unclear, that has to be accepted.

And anything that those whose why part is unclear, especially when it comes to human bodies medicine is dubious, would you like to take any medicine, which you do not know how it cures you, but someone has said that it cures I have known. Would you like to take it, maybe you would but I am skeptical in that regard.

So, remember, these are some of the general introduction of tissue engineering with laser. There are several other topics as well. So, we need to we need to go on to that as well. In the next two classes, I will take specific examples I will try to see how laser eye surgery is done, different

types of laser eye surgery or thermal logical application and I will utilize the last chapter of this particular module on application of laser on dentistry, how laser can be directly used on dentistry.

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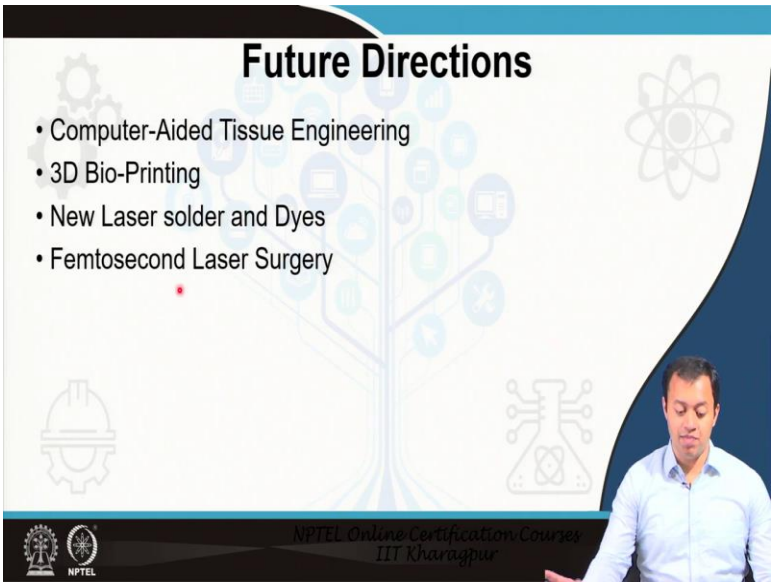

So, what are the future direction, the future direction as I said, 3d bioprinting and femtosecond laser surgery is coming up that dissipates the heat in a completely different way, localize the heat without destroying anything else. And Computer Aided tissue engineering, these are some of the future direction. People keep on asking what are the hot topics? So, 3d bioprinting is a hot topic when it comes to bioengineering.

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So, these are my concepts.

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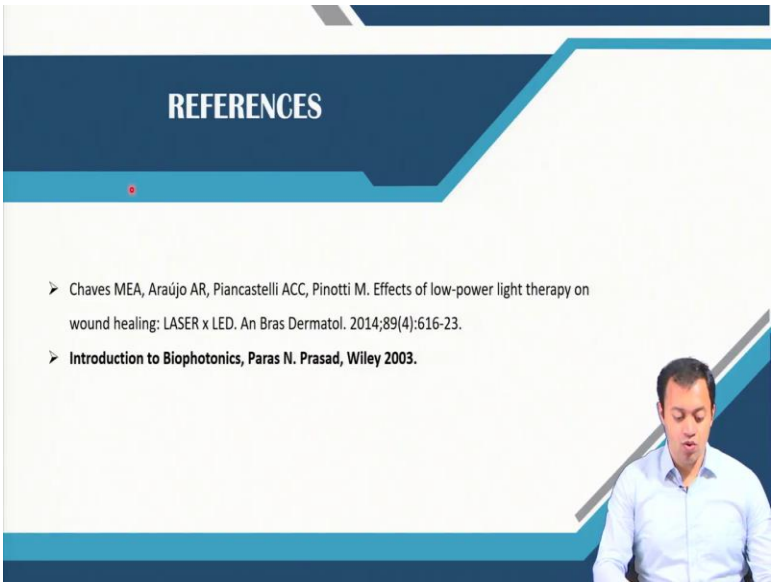

And these are the references go through some more of light power, light, low power light therapy, and make up your own mind, make an informed decision. That is all I want. You do not have to accept or reject anything, whatever you do know the full consequences around it. So, thank you. Thank you very much. I shall see you in the next classes. Thank you.