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Patching Up Skin Cancer with Silicone Needles

Dr. Greenberg:
Melanoma is one of the most fatal forms of skin cancer, and traditional treatments for this disease are invasive and often lead to serious side effects, but with emerging research in the therapeutic landscape, clinicians may have discovered an alternative treatment with very minimal side effects.

Welcome to *Derm Consult* on ReachMD. I'm Dr. Michael Greenberg, and joining me today to discuss an innovative new treatment option for skin cancer is Professor Chi Hwan Lee, an Assistant Professor of Biomedical Engineering and Mechanical Engineering at Purdue University.

Professor Lee, thank you for being here today with us.

Professor Lee:
Thank you. It is great to be here.

Dr. Greenberg:
So, to start, we want to know a little bit about you. Can you tell us about your educational background?

Professor Lee:
So I've got a PhD degree in Stanford University Mechanical Engineering, and I did a post-doc training in Material Science Engineering at University of Illinois Urbana-Champaign under the provision of Professor John A. Rogers, and I joined Purdue University in 2015 as an assistant professor.

Dr. Greenberg:
Okay. So I'm fascinated by this idea of silicon needles as a delivery system of chemotherapy. Can you tell us about it and how you got involved with it?

Professor Lee:
Sure. This invention is a novel bioresorbable skin patch that includes fully miniaturized nanoneedles on a thin, flexible, and water-soluble medical film, which is tailored for painless and unobtrusive delivery of chemotherapeutics to manage melanoma. For instance, this water-soluble medical film is temporarily used to deliver the nanoneedles to the target site of the skin and then immediately dissolve by applying saline solution within minutes.

Dr. Greenberg:
So, when it's put on your skin, do you feel the needles, or are they so small that there's no sensation?

Professor Lee:
It's too small to feel. It cannot be seen by eye. It's very small at the nanoscale.

Dr. Greenberg:
I believe I saw in your paper that this can actually be put on the cornea. Is that correct?

Professor Lee:
Yeah, it is correct. It can be delivered to cornea or skin.

Dr. Greenberg:
So, tell us, how did you get involved with this project? Was it something you brought to Purdue or something Purdue had?

Professor Lee:
So, as is often the case with children, my 7-year-old daughter, Jane Lee, hates having shots, so her wish for painless shots drive me to invent these nanoscale needles, so I wish I could have unnoticeable needles by eye that can be also penetrating to the skin in an imperceptible manner, or painless manner, so that she cannot feel any pain during or after injection.

Dr. Greenberg:
Professor Lee, are you doing this as a solo project, or do you have collaborators?

Professor Lee:
I have collaborators. I've been collaborating with Professor Yeo here at Purdue Pharm and Professor Dong Rip Kim at Hanyang University in South Korea.

Dr. Greenberg:
Okay, so let's kind of turn back to melanoma for a minute. Concerning chemotherapy for melanoma, how is a silicon delivery different for chemotherapy?

Professor Lee:
So, comparing to other conventional miniaturized microscale needles that are typically made of bioresorbable polymers at the microscale, our nanoscale needles, silicon needles, are at least 30 times smaller and provide 10 times longer-lasting release of drugs so enabling less invasive and longer sustained treatment of melanoma.

Dr. Greenberg:
Based on your experience, what are some of the advantages and most importantly the disadvantages of using silicon needles? There's always got to be a dark side.

Professor Lee:
Yeah, so the key or the advantage of these nanoneedles, as I just mentioned before, this is much smaller than conventional microneedles, and it can provide at least more than 10 times longer-lasting release of drugs—so it is much smaller, and it can deliver the drug molecules over much longer period of time comparing to microscale, polymer-based needles. That's the good advantages, the key advantages of these needles. The downside of this is the complication of fabricating nanoscale, vertically aligned needle structures. It takes more effort to fabricate it, so it involves using nanofabrication technologies.

Dr. Greenberg:
Okay. So tell us, how are these needles manufactured? Where are they manufactured? And how do they get modified for individual patients?

Professor Lee:
Okay, the silicon nanoneedles are fabricated using conventional nanofabrication facilities, the clean facilities more specifically, so it begins with the conventional silicon wafer, and we apply photolithographic patterning and dry etching to generate micropillars on top of silicon wafer, first of all, and then we shrink down so that these micropillars become nanoscale needles on top of silicon wafers. So what we did is we actually physically—we generate controlled crack to physically separate these nanoneedles from the fabrication silicon wafer and then transfer them on to the bioresorbable, medical grade patch. This is how we actually fabricate it.

Dr. Greenberg:
Well, how are they individually modified for patients?

Professor Lee:
Actually, we didn't modify the size for individuals. The size of silicon nanoneedles can be modulated to change the drug-loading amount and to also change the drug-loading profiles, but we didn't modify the size and surface of the silicon nanoneedles depending on patients.

Dr. Greenberg:
Okay. So, is the medication put in before the manufacturing or after they are manufactured?

Professor Lee:
After the manufacturing. So we fabricated this silicon nanoneedles on top of bioresorbable patch, first of all, and then we loaded the drug on the surface of each silicon nanoneedle by using covalent chemical bonding mechanism.

Dr. Greenberg:
Okay. For those of you just tuning in, you're listening to *Derm Consult* on ReachMD. I'm Dr. Michael Greenberg, and today I'm

speaking with Professor Chi Hwan Lee about his really interesting research on a wearable patch that could be a new option for skin cancer treatment.

So, are these needles actually being used these days, or is this still research?

Professor Lee:
Currently, it is being studied on animal models. More specifically, we're testing the silicon nanoneedles on mice melanoma model.

Dr. Greenberg:
If you think down the road, besides melanoma, what other medications do you think these needles are appropriate for as a delivery system?

Professor Lee:
Currently, actually, my team is working on this project to seek another opportunity to utilize the silicon nanoneedle platforms for the sustained drug delivery to treat ocular diseases because the eye is much more smaller and sensitive comparing to the skin, so we thought that these nanoscale needles can play more important role for ocular drug deliveries.

Dr. Greenberg:
Okay, so you've been testing it on mice. Have you put any of these patches on a human eye and asked the person how it feels?

Professor Lee:
None yet. We have tested it on rabbit and mouse model.

Dr. Greenberg:
So I'm going to ask the question then because you said it's so small and you won't feel it. How do you know? How do you know you won't feel it?

Professor Lee:
Oh, we haven't verified it. I say that based on the fact that these nanoneedles are at least 30 times smaller than the micro polymer needles. And even for the micro polymer needles, they have verified that it's a less painful delivery method for animal models, so based on that fact, I believe that these nanoscale needles have much less pain level comparing to these microneedles.

Dr. Greenberg:
All right. You're putting this patch on locally, which means that you're only looking at melanomas, for instance, of the skin, correct?

Professor Lee:
Mm-hmm.

Dr. Greenberg:
Are you looking at this as an adjunct to other chemotherapy or just looking, for instance, for melanomas in situ where they haven't really spread? Because you may have internal spread of that melanoma, and you're going to need other chemotherapy besides your patch.

Professor Lee:
Actually, what I envision is that we want to use this silicon nanoneedle platform to prevent melanoma relapse. For instance, the melanoma relapse after surgical resection remains a significant challenge in the treatment, so the systematic chemotherapy and radiotherapy are ultimately employed, but these methods may lead to toxic side effects, so I believe that our nanoneedle patch may reduce the risk of tumor relapse with minimal side effects by enabling sustained local delivery of therapeutic drug molecules with precisely controlled doses for prolonged time after surgical resection.

Dr. Greenberg:
So let me ask you to look way down the future because of the way technology is exploding on a logarithmic scale in our world. Ten years down the road, 15 years down the road, where do you see these microneedles in play in a broader field of medicine? It's got to be able to be used for more than just melanoma and eye diseases. What's your vision?

Professor Lee:
So, although the current research focuses on the treatment of melanoma, this drug delivery platform can be applicable for many other cancers or ocular diseases, so my long-term goal is to create almost unnoticeable needles that can be penetrating to the skin or cornea in an imperceptible manner without pain during and after their injection.

Dr. Greenberg:
What about using other medications, chronic medications, with this?

Professor Lee:
Yeah, it can be anything that can be attached to the silicon surface using covalentbonding, so it can be antibiotics, or it can be any other types of cancer drugs and so on.

Dr. Greenberg:
Well, that's all the time we have for today, but I want to thank Professor Lee for providing insight into this fascinating new treatment option and discussing the treatment landscape for melanoma. Professor Lee, it was great speaking with you today.

Professor Lee:
Thank you very much. It was great being here today.

Dr. Greenberg:
For ReachMD, I'm Dr. Michael Greenberg. To access this episode and others from *Derm Consult*, visit ReachMD.com/dermconsult where you can Be Part of the Knowledge. We thank you for listening.