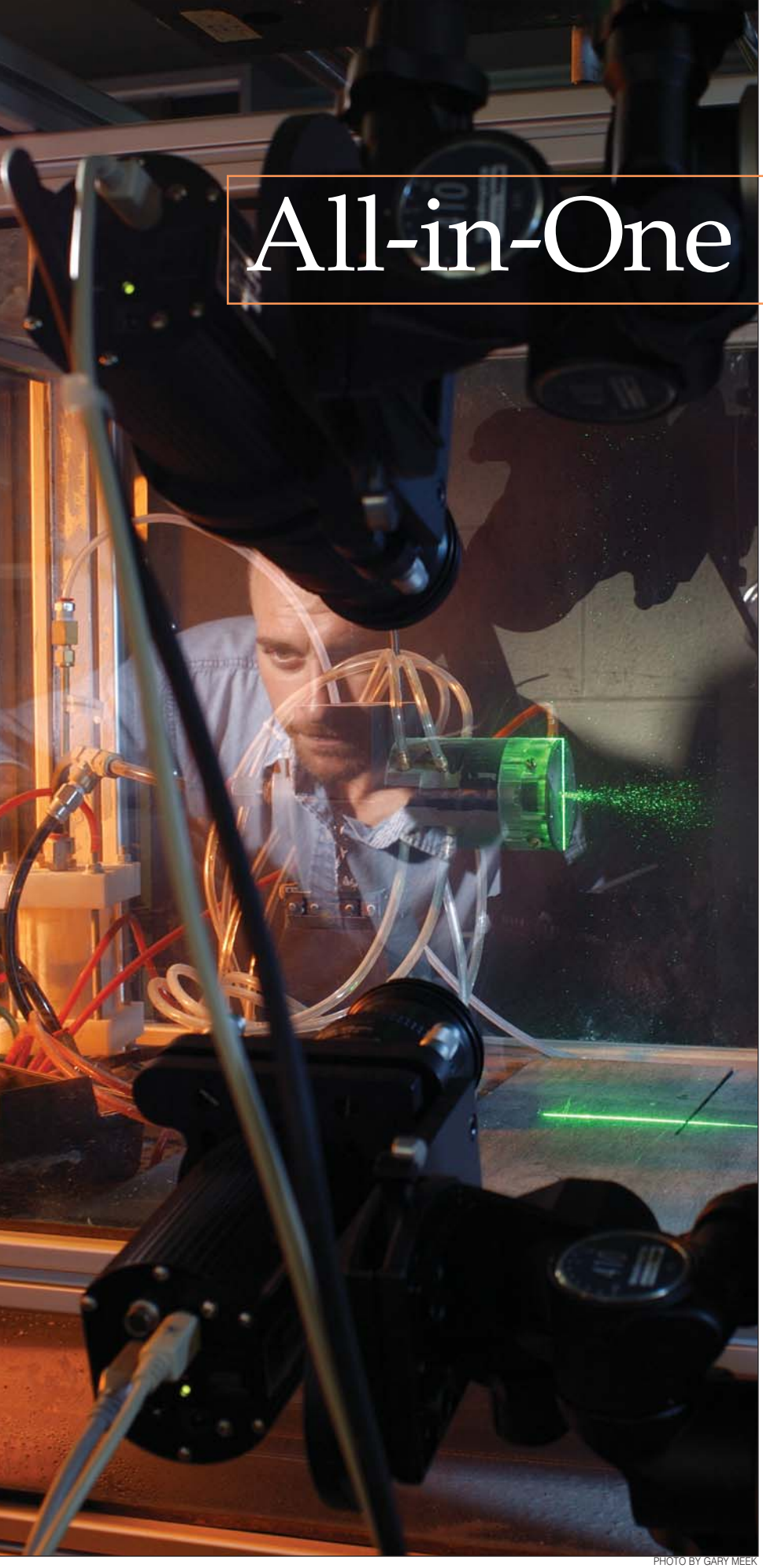

PHOTO BY GARY MEEK

All-in-One TOOL

Researchers use aerospace technology for one-step dental tool.

by T.J. BECKER

Researchers at the Georgia Tech Research Institute (GTRI) are transferring aerospace technology to dental tools.

A project that grew out of GTRI's Health Initiative Program, the overall goal is to create a single dental tool that will handle all conventional procedures – cavity removal, fillings and preventive treatment.

"This one-step dental tool will provide faster, better treatment and should ultimately lower costs," says Shayne Kondor, a research engineer in GTRI's Aerospace, Transportation and Advanced Systems Laboratory.

"We're trying to make dentistry more precise, especially for micro-dentistry techniques where small areas are hard to reach with conventional tools," says Michael Amitay, a former GTRI research engineer who is working on the project from his new post as assistant professor in the Rensselaer Polytechnic Institute's Department of Mechanical, Aerospace and Nuclear Engineering.

The first phase of the project, which began last year, has focused on removing decay as engineers try to improve the particle-laden jets used in air-abrasion devices.

Dental air-abrasion technology, which, instead of a drill, uses aluminum oxide particles to remove tooth decay, has been in use for almost 60 years. Yet current air-abrasion techniques have drawbacks that limit their acceptance among dentists. For example, there's a significant amount of abrasive material to contain and remove, and it's difficult to remove moist decay.

"The particle-laden jets used currently in air abrasion have no feedback control for dentists to monitor and adjust the particle stream," says Kondor. "What we're trying to do is to create a sort of auto-pilot system for the dental jet that

makes it more precise and effective."Kondor and Amitay presented a paper on the project at a joint conference of the American Society of Mechanical Engineers and the Japan Society of Mechanical Engineers held in July 2003.

To gain better control over the particles used in air abrasion, Amitay and Kondor have been experimenting with passive and active flow control techniques commonly used in aerospace engineering.

Flow control is about applying processes to make the flow of air behave differently than it normally would. Passive flow control modifies a flow of air without adding energy, such as the vortex generators used on an aircraft wing. Researchers have experimented with putting small pins in the particle-laden dental jet that alter the flow of air. But they're getting better results with active flow techniques.

In active flow control, energy is added to the flow, such as introducing an additional air stream into the main air stream of the particle-laden jet — an example of steady active flow control. Researchers have tested steady active control at two different angles – 45 and 90 degrees – with promising results. They're also investigating techniques, including synthetic jets, for unsteady active flow.

With synthetic jets, air is alternatively pushed in and out of an orifice. Because the device uses surrounding air rather than introducing a new source of plumbing, it's more efficient, cheaper and easier to construct."We should be able to reduce the energy we put in by at least an order of magnitude and get the same results with synthetic jets as with steady active flow,"Amitay says.

Besides improving air-abrasion techniques for cavity removal, the researchers want to create a dental tool that reverses modes – from material removal to material replacement. That way, the same device could remove decay, add the right composite filling materials and perform preventive treatment, such as fluoride application.

This one-step device would solve several problems that dentists encounter, says Dr. Frederick Rueggeberg, a professor at the Medical College of Georgia who is collaborating on the project. For starters, dentists must stock an extensive variety of tools and materials to address different goals when doing a restoration. Case in point: A filling in the back of the mouth needs to be very durable, restorations along the gum line need to be more flexible and those in the front of the mouth must be highly aesthetic.

To eliminate the need for dentists to stock multiple premixed composites, Amitay and Kondor envision a dental jet that stores the binder and filler materials separately. Then, with a touch of a button, dentists could control the ratio between the binder and filler to modify the stiffness, strength and aesthetic qualities of a restoration.

Another improvement: The binding material, a monomer mixed with filler particles, would be injected as droplets instead of bulk placements with the viscous gel that dentists use now. This would allow the deposited mixture to adapt better to intricacies of the tooth preparation, Rueggeberg says, explaining that premixed composites are uniform in consistency and can't always reach small pockets.

Yet another aspect of the project will be to incorporate exposure to ultraviolet light into the one-step dental tool, which will uniformly cure the binder and filler materials as they are applied. Currently, dentists have to apply the composite material in several stages, which results in shrinkage and also increases the time needed to perform a tooth restoration.

In total, the one-step dental jet will eliminate the need for separate drills, a variety of hand instruments, different restoration materials and a separate light for curing.

"In a dental office, time is money. All of the small steps required now add up to significant amounts of time that could be saved with such a tool,"Rueggeberg says.

The one-step dental tool could help military dentists perform procedures more easily in the field."There are also many underserved areas of the country that could benefit from this device," Rueggeberg says."Anything that you can do to reduce hardware will greatly benefit dentists and their patients."

Beyond dentistry, this technology has other medical applications, such as orthopedic and reconstructive surgery."It could be used in a situation where you need to build a piece of missing bone or modify the shape of hard tissues that are naturally deformed,"Rueggeberg explains.

One of the challenges that researchers face as they move forward is scaling down their experimental prototype."When we began to study the dental jet, we either had to build our own instruments and lab to evaluate our technology – or find a way to use existing flow-visualization equipment at GTRI,"Kondor says. They opted for the latter, enlarging the particle-laden jet about 10 times its normal size.

"Now one of our big questions is if the technology will perform the same way when we scale it back down,"Kondor says.

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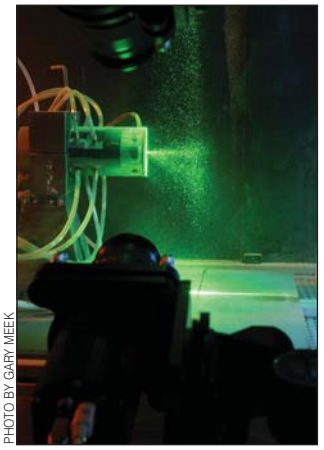

PHOTO BY GARY MEEK

To gain better control over the particles used in dental air abrasion technology, GTRI researcher Shayne Kondor, pictured at left, and his colleagues have been experimenting with passive and active flow control techniques commonly used in aerospace engineering.

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