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NEW FACES FOR OLD DUMMIES

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In response to US Dept of Transportation SBIR solicitation SBIR-90-1, subsection 90-NH5, Triangle Research and Development Corporation submitted a proposal for the development of a facial laceration measurement mask for anthropomorphic models. They were awarded a contract (DTRS-57-90-C-0014). Funding for this project has now been authorised.

A review of the existing literature on this subject has revealed three key factors which the project will address.

1 The Triplex laceration index (TLI) [1] has been accepted and is widely used as a yardstick for the quantification of facial lacerations. The chamois laceration scale (CLS) is a simplified method of measuring laceration potential that is also commonly used [2]

2 The "standard" covering now used for the Hybrid III facial dummy used in research in this field consists of two layers of chamois leather, often moistened. There are problems with respect to the use of this simulation both in terms of consistency and realism. Furthermore the methods by which this "covering" is applied to the anthropomorphic head are neither uniform nor satisfactory

3 Synthetic materials which have been used as an alternative to chamois (namely LAB265, a polyurethane, and RTV 1502, a silicon) approach the mechanical properties of traumatised cadaveric skin to a great extent, but both are homogeneous materials, which skin is not. There are problems in achieving realism in respect to the fact that facial skin is not only variable in its thickness and mechanical properties but also to the fact that its fixation to the underlying skeleton varies with site. To these variables are added those of age and racial characteristics (and also pathological states).

The object of the phase 1 proposal is to produce a material, likely of a composite nature, which can more precisely and repeatedly simulate the mechanical properties of facial skin which pertain in life. In so doing consideration must be given to the method by which the mask is "interfaced" to the Hybrid III dummy, though the details of this, and the possible sophistication of the underlying dummy's "skeletal" properties, will hopefully form the substance of a phase II effort.

BACKGROUND

TRDC has already successfully developed a lung model which is now being used for teaching diagnostic and operative bronchoscopy.

It is highly realistic. These are bronchoscopic views of the lung model

Much of the materials knowledge acquired in the development of this product (whose structure is based on actual casts of human lungs) will be used in producing articial skin. Moreover TRDC is currently developing models as part of another SBIR grant for the simulation of small blood vessels with the object of making a microvascular surgical simulator aimed at diminishing the need for using animals for the purposes of instruction and learning of these techniques.

These are the appearances of the rat femoral artery undergoing microsurgical anastomosis.

Prototypes have already been developed which closely mimic the physical properties of the rat femoral artery (the experimental model most widely used for this purpose until now). These incorporate much of the lung model technology as well as further sophistication in producing "reality", both visual and mechanical. A programmed pump will provide pulsed circulation of a blood substitute. In passing we feel that there are many other developments now possible in surgical simulation.

At this time it is envisaged that, eventually, the "new" skin for the face mask to cover the Hybrid 3 dummy will be variable in its consistency and thickness. (Eyelid skin and scalp skin are quite different in both appearance and mechanical attributes. Feel the skin in those two areas for yourself now to confirm that).

The material will almost certainly have enmeshed within it a fiber-like structure. This would appear necessary to address the observations, long known, that relate to Langers lines. A digression is required here.

Carl Von Langer, Professor of Anatomy at the University of Vienna in the mid 19th century has his name firmly attached to some lines. Langer's lines. What are these lines? Originally they were thought of as lines of cleavage. And they were associated with the observation that bundles of collagen in the human dermis are mostly arranged in parallel. In animals, interestingly, this is not universally true.

In practical terms this arrangement produces physical characteristics which lead to the formation of a linear wound after the skin has been breached by a conical object. In other words the collagen bundles have been forced apart at the time of injury and have realigned themselves afterwards.

Such considerations are obviously important with regard both to laceration patterns and to the formation of scar tissue. For this reason surgeons have traditionally been advised to place surgical incisions parallel to Langer's lines.

Langer's lines are frequently referred to in the language of clinical practice and the jargon of scientific publications, including those related to motor vehicle accident research.

However recent investigations by plastic surgeons have shown that Langers lines are not synonymous with what they call "lines of election" for scars. For it is now known that Langer's lines more often than not bear little relation to the lines of election. The term Langer's lines is likely to linger on however in clinical parlance, though often it is really the lines of election that are being described.

Furthermore there are various factors which contribute to the propensity for scar formation. These include race, age , anatomical site, nature of injury, degree of wound contamination and many others. And, for the same set of circumstances, there is considerable individual variation in scar formation, the reasons for which are incompletely understood.

Going back to the simulation we feel that by designing the fiber alignment to comply with what we might call the "Langers lines arrangement", in other words the collagen bundle arrangement, a skin simulation will be more realistic particularly with respect to its injury patterns, which is the whole purpose of the projected work.

Considerable expertise already exists in the simulation of the appearance of facial skin. That is visible in many museums where uncannily lifelike "wax" mannequins are used in displays. But these do not of course have to simulate any mechanical properties, particularly injury response.

This mechanical response is a complex matter to simulate. For the characteristics of the underlying bones of the face and skull determine, to a significant extent, the way in which skin overlying specific sites may be deformed or traumatised. And in addition, as has been mentioned already, the amount and nature of loose connective tissue between the skin and the skeletal structures also has an effect on the laceration potential of skin to given traumatising forces. It is for these reasons that the Phase I effort will be devoted to the skin alone. But due consideration, in the course of this work, must also be given to the development of what I may call an "intermediate mask" or "spacer" to fit between the skin mask and the skeleton, since fixation of the chamois model has caused problems.

Our Phase 1 task will require that the new facial skin mask be tested using standard methods both for simulating injuries and recording their effects, so that it may be properly compared with the performance of chamois leather.

We are already looking forward to a Phase 2 effort which would not only sophisticate the skin, and more particularly its supporting soft and hard tissues, but also provide a new way of recording lacerations. Contact has already been made with a British group working on skin simulation and such other information as is available from other sources will be incorporated into our strategy in order not to duplicate effort and waste resources, and to minimise development time. And of course we would welcome any input from this group which could facilitate the successful production of the proposed simulation.

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SPEAKER: Neil Watson, Triangle Research and Development Corp.

QUESTION: John Melvin, GM Research Labs, Biomedical Science

In the example that you showed of the windshild injuries, I believe that appeared to be a tempered glass windshild not an HPR windshield, is that correct?

A: I'm not able to answer that, I do not know because that slide is very old. It just happened to be in my clinical collection after a visit to the road research laboratories in Crawthorne. The slide is almost twenty years old.

Q: We wouldn't expect to see that type of injury in a modern American automobile?

A: If I may say, though, the clinical slide that followed that slide was taken about four years ago.

Q: With a tempered glass windshield?

A: I cannot answer that, I do not know.

Q: The large cutting would be reminiscent of hitting on the edge, of the glass rather than an HPR windshield. In your work, are you going to consider the type of failure that seems to occur in soft tissues when struck in blunt impact, the splitting of tissue in that situation? It appears as a laceration but there's no cutting involved.

A: Our contract involves conducting fairly simmple tests using a device whose name I don't know, perhaps you know, Rick.

A: Richard Morgan, NHTSA

I think the answer is that the proposal is to key in on the cutting of the external surface of the skin, the knife type cutting. The proposal is not to focus on the type of impact where there is a blunt object that comes in and causes a laceration.

A: This is specifically addressing laceration potential and response.

Q: Do you think that's a good idea John?

A: John Melvin - Well, there's been a lot of work done on that particular issue but it seems to me, particularly with HPR windshields, you may be faced with a blunt splitting as opposed to an actual laceration of a major sort. We see this in instrument panel impacts to the face, also in living people. You split the tissue, there's no cutting involved. The cutting may come from the underlying bony structures. In fact, in infants and children

you can palpate the start of one of these failures. It starts from the inside out. According to the clinicians that I talked to, if a child hits their forehead against a blunt surface, you can feel the split tissue underneath but it has not ripped the skin yet. So, there's a completely different mechanism, one would suspect, and therefore, may require a different way to look at your mechanical properties for that purpose.

You talk about experiments. Do you intend to do any biomechanical experiments. This seems to be the area where we have very little data. How are we going to compare this to a real situation?

A: We certainly do. We are allied with another group in the same city who are, at present, conducting biomechanical tests of dog abdominal wall skin. So, the technology for measuring the skin, and subsequently, the skin simulation will be available to us. We are just arranging to do that right now.

A: Rick Morgan - The laceration is quantified by experiments that Dr. Tarriere and his team did at the Association of Peugeot-Renault. These first experiments were followed again by Dr. Murray Mackay and his team at the University of Birmingham in the U.K. In your knowledge, does there exist any qualifications of the type of laceration that you get from a blunt impact? Could you recommend some place in the literature where we could look.

A: John Melvin - No, I think that's an area that researchers should study because it does not seem to have been covered. Many years ago, Charlie Gadd started looking at this but I don't think he generated much information. He looked at cutting and blunt impact in the tissue that was available to him. I don't know that it was necessarily a phenomenon that he could create in this experiment.

A: Neil Watson - I think you made a comment, in passing, which adds to the difficulties of the simulation because you said that you could feel a dent, as it were, in a child's forehead. The operative word is "a child" because if that person had been eighty years of age, you would't feel the same thing at all.

Q: John Melvin - That's right, but it's only an indication of the process. It starts underneath and comes out as opposed to coming from the outside in, and would be characteristic of the mechanical conditions that seem to occur under a rapid, blunt impact.

Q: Claude Tarriere, Association of Peugot-Renault

I think this is a tempered windshield. It probably disappeared completely from Europe, some years ago. We have similar windshields, in Europe, now, as in the United States. Are you aware of the work that we did, maybe fifteen years ago, in this area? We cut fresh skin and did the work the same day that we got it. It was a dynamic drop test using specific tools. We used the same tools for fresh skin and for the different materials, such as p lastic materials. On this basis, we selected a silicone material

which has very appropriate behavioral properties. It behaved similarly to human skin. However, I have no answer to the question John asked, that is to say, is there a difference in the type of laceration in the two different mechanisms? So, the question is, did you notice all of the work reassess our understanding of the situation on the basis of the new car environment in the real world. Our facial data, that you mentioned, is probably of the real world but it was some years ago, with tempered windshields. In any case, laceration was the first priority for facial impacts. In terms of quantities of injuries, it is difficult to compare laceration and brain injury induced by a facial blow.

Q: Guy Nusholtz, Chrysler

This is more of a comment related to what John was talking about. I've seen some results from tests on both cadavers and live primates in which a blunt object, in this case, a flat piece of material, struck either the face or the shoulder. We were able to produce a laceration just by the fact that it was moving fast enough. I just wanted to mention that it has occured in a laboratory type of environment.