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Johnson - Introduction ICMS December 8, 2021

One of the focuses of this year's presentations is PPE Personal Protective Equipment. Helmets have been an important part of protective devices since humans realized the importance and necessity of protecting one's head.

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Early headgear served as protection from penetration wounds in the head by sharp and heavy weapons like axes, maces, and swords, not from impact injuries to the brain by falling.

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As the need for a helmet for self defense in battle subsided, humans continued to find ways to damage their heads in recreational activities.

The development of protective headgear in personal and team sports began to considers preventing injuries caused by more blunt trauma and impacts, rather than sharp objects.

1920s – 50s and 70s football (Baltimore, not Indianapolis Colts)

Automotive racing helmets in the 1950s were not much more than paper mache and leather, some with suspension devices to mitigate minor impact loads.

By the mid 60s, protective headgear used in racing developed into a more familiar design and better protection from impacts.

Snell had stepped in.

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Helmets have graduated into critical protective devices which dramatically reduce injury rates in activities such as bicycling, equestrian, motorcycle use and competitive automotive sports.

Improvements in manufacturing processes and better shock absorbing materials, like carbon fiber, continue to raise the level of head protection available to professional athletes. These benefits are passed down to consumers looking for the optimal head protect affordable.

More recent additions are electronic connective devices like internal video cameras and communication gear in more manageable size and mass, reducing possible hazards to users.

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The Snell Foundation has provided a public service to examine, review and encourage continued development and improvement of protective headgear. The Foundation exists because an amateur race driver fatally injured in a crash when his personal protective equipment was inadequate, most notably his helmet.

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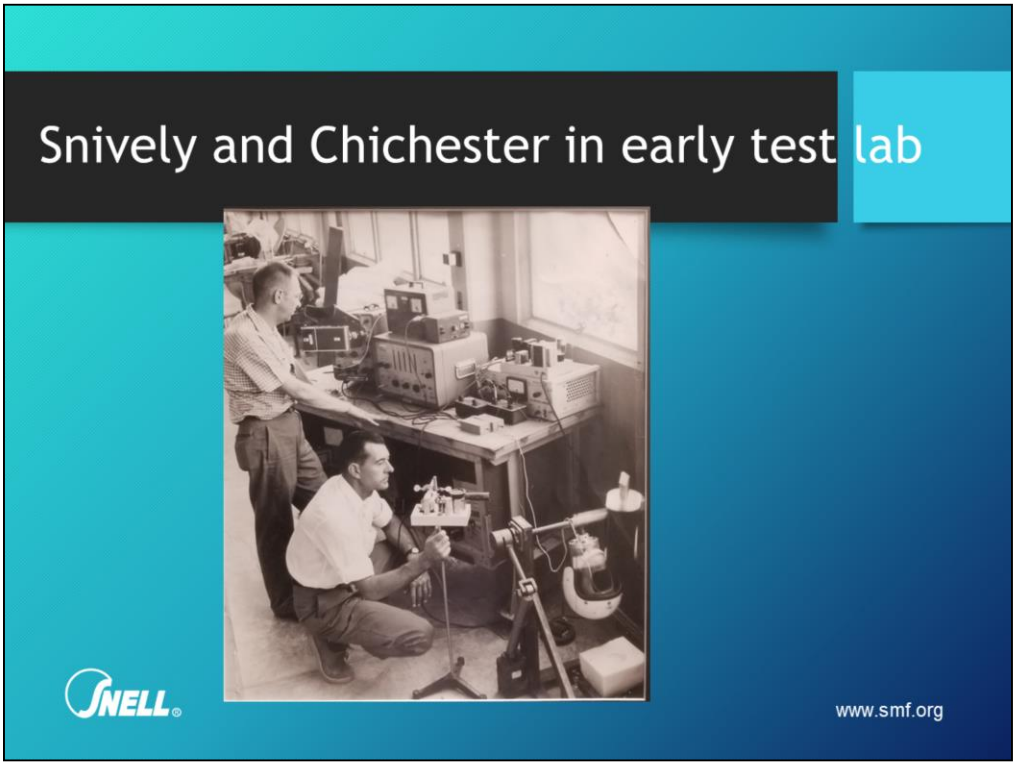
William “Pete” Snell died of head injuries received in an amateur racing crash in 1956. He had been wearing what was then a state-of-the art helmet that failed to prevent fatal head injuries in a survivable crash.



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Snell Memorial Foundation was founded by friends, family and colleagues determined to reduce head injuries and increase performance of safety equipment used in automotive competition.

Dr. George Snively was a driving force in developing test methodologies and standard requirements, as well as acceptance by the racing organizations of Snell certified protective headgear.

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Snively’s commitment to the racing community is recognized and was admitted to SCCA (Sport Car Club of America) Hall of Fame 2015.

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Snell standards are reevaluated every five years to recognize changes in technologies, applications, and user and industry needs.

The Snell lab continues its work to identify the best performance available to helmet users.

The testing performed is vital in maintaining the Snell standards and certification program.

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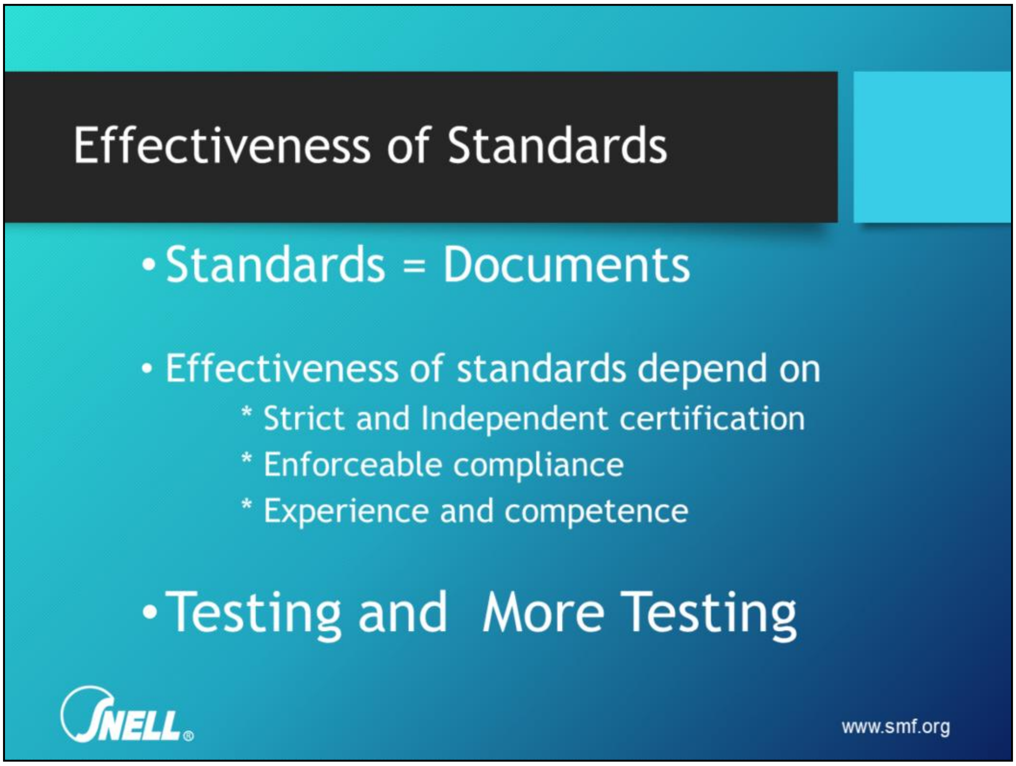
1. The Foundation needs evidence to produce standards that are meaningful and viable.

2. The Foundation's goal is to identify the most protective helmet available for activities requiring protective headgear.

3. Snell spends a great deal of energy educating parties and individuals about the benefits of helmet use, and identifying optimal headgear.


Effectiveness of Standards
• Standards = Documents
• Effectiveness of standards depend on
* Strict and Independent certification
* Enforceable compliance
* Experience and competence
• Testing and More Testing
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The Snell Foundation has been investigating rotational response to impact. The current effort is based on a particular methodology involving full head forms equipped with six degree of freedom instrumentation and an oblique impact surface. There is no neck. This particular methodology assumes that throughout the short duration of the impact event, the effects of a neck and torso are negligible and that the only factors to be considered are the interactions between the impact surface and the helmet and then the helmet and the head form. This is only one of the several methodologies currently in use elsewhere but it is the only one called out in current helmet certification programs.

As a necessary part of this effort, we have looked into methods to establish that the test systems are working correctly. However, most of the effort has been devoted to helmet performance and, particularly the differences in performance observed for helmets equipped with novel, rotational mitigation features.

Introduction of Denis.

We Don’t Make Helmets.
We Make Helmets Safer.

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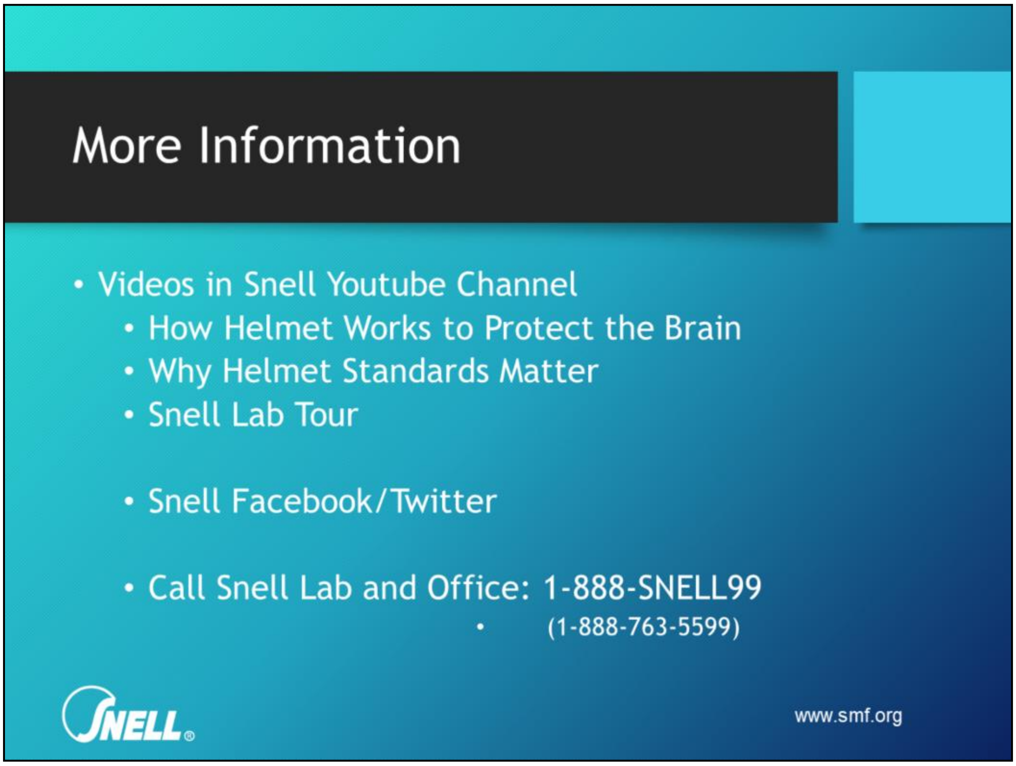
More Information
• Videos in Snell Youtube Channel
• How Helmet Works to Protect the Brain
• Why Helmet Standards Matter
• Snell Lab Tour
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• Call Snell Lab and Office: 1-888-SNELL99
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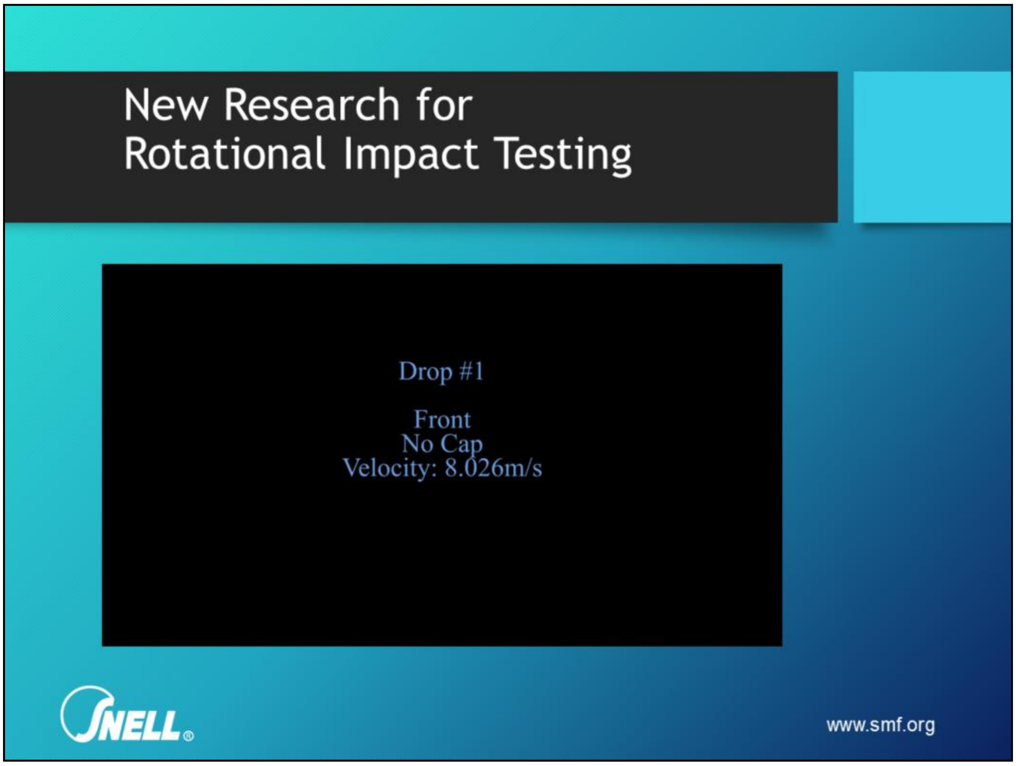

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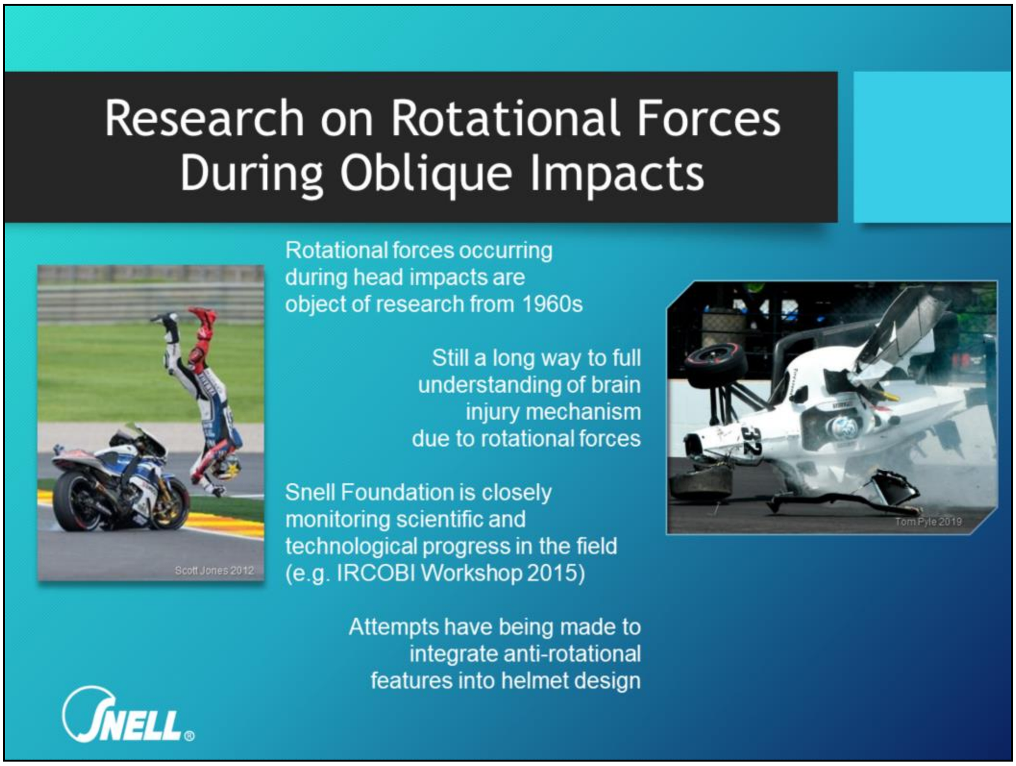
Snell examining rotation mitigation devices.

Test Drop video URL: https://smf.org/video/ObliqueImpactPrsnt.mp4

The video shows a helmeted head form falling onto the oblique anvil. The forty-five degree tilt of the impact surface separates the nominal 8 meters per second drop velocity into normal and tangential components of 5.66 meters per second each; effectively a fall from about 1.65 meters while cruising at a velocity of about 12.5 mph. Friction between the helmet shell and the 80 grit sandpaper applied to the anvil surface effectively applies a torque to the helmet shell which, depending on the helmet configuration and the coupling between the head form and the helmet interior, is passed along to the head form. Instrumentation in the head form captures all three components of translational acceleration and of rotational velocity which can then be downloaded and analyzed.



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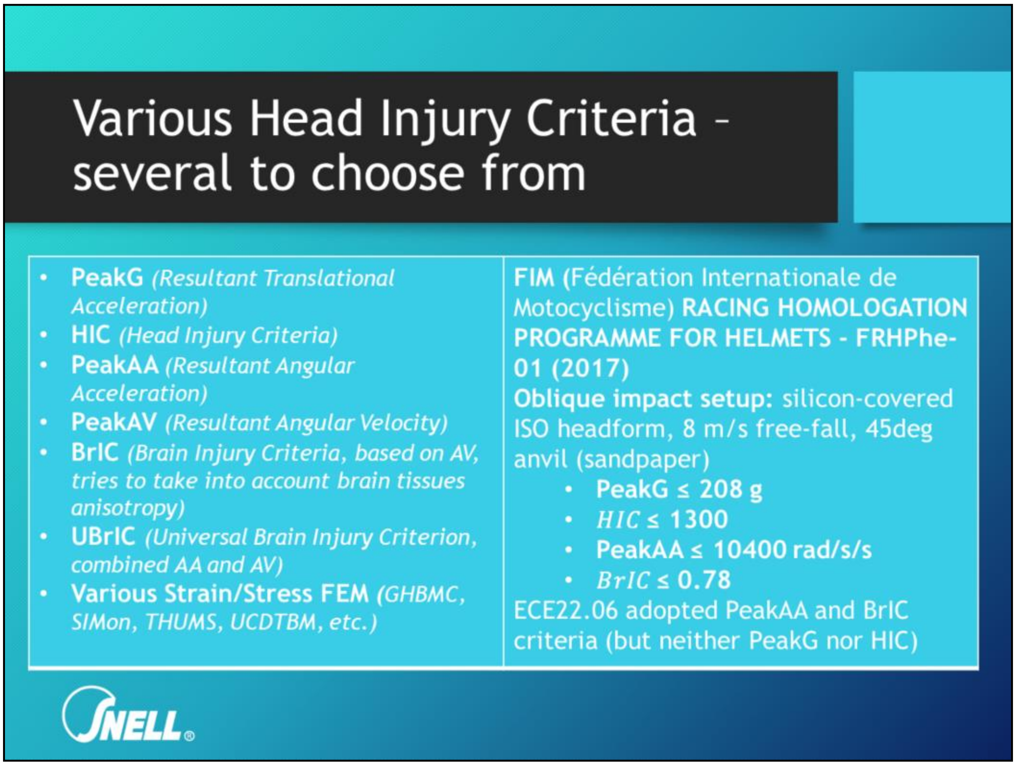
Since its inception in 1957, the Snell Foundation and biomedical research have begun to appreciate the role of rotational or angular head motions as a cause of certain brain injuries. Impact induced rotation was proposed as a cause of brain injury by Dr. A.H.S. Holbourn in the early 1940's . In 1964, Dr. A.K. Ommaya published the first of many papers that documented rotationally induced concussion in non-human primates and postulated that a particular form of brain injury, namely concussion, could only be caused by rotational motion. Later, in 1982, Gennarelli and others found the same for a more severe injury which they named diffuse axonal injury.

Snell's staff and its Board of Directors have been paying close attention to studies of the biomechanics of rotation and its implications for brain injury. Dr. Thomas Gennarelli, who served on Snell's board of directors until his retirement in 2018, published in this area. The results of his experimentations are the basis for much of current thinking about human tolerance for rotational acceleration and its effects on the brain.

Even so, most traditional helmet testing and helmet standards are concerned with translational rather than rotational motion. Rotational responses are not included in the measurements and the testing itself is structured to minimize any rotational response. Still, these traditional methods have been successful. Epidemiological studies have demonstrated significant reductions in the risk of serious injury for drivers and riders who crash wearing current qualified headgear. However, although helmets reduce the incidence of skull fracture and focal brain injury, there is concern that concussion and diffuse axonal injury are not being properly addressed in current helmet standards and helmet test methods.

In 2015 the Snell Foundation was one of the co-sponsors of an International Angular Head Motion workshop conducted under the auspices of IRCOBI, the International Research Council on Biomechanics of Injury. Experts in helmet standards and testing, biomechanics, finite element modeling, medicine and other related fields gathered to discuss impact induced rotation, its hazards, human tolerances, protective measures and test methods. A summary of the workshops findings is available but there was no consensus at that time either for test methods or standards. Since then, several test methods have come into use, more than a few devised by helmet makers to promote helmets novel, anti-rotational features, and FIM has published a helmet standard which includes oblique impact along with angular motion measures and criteria.



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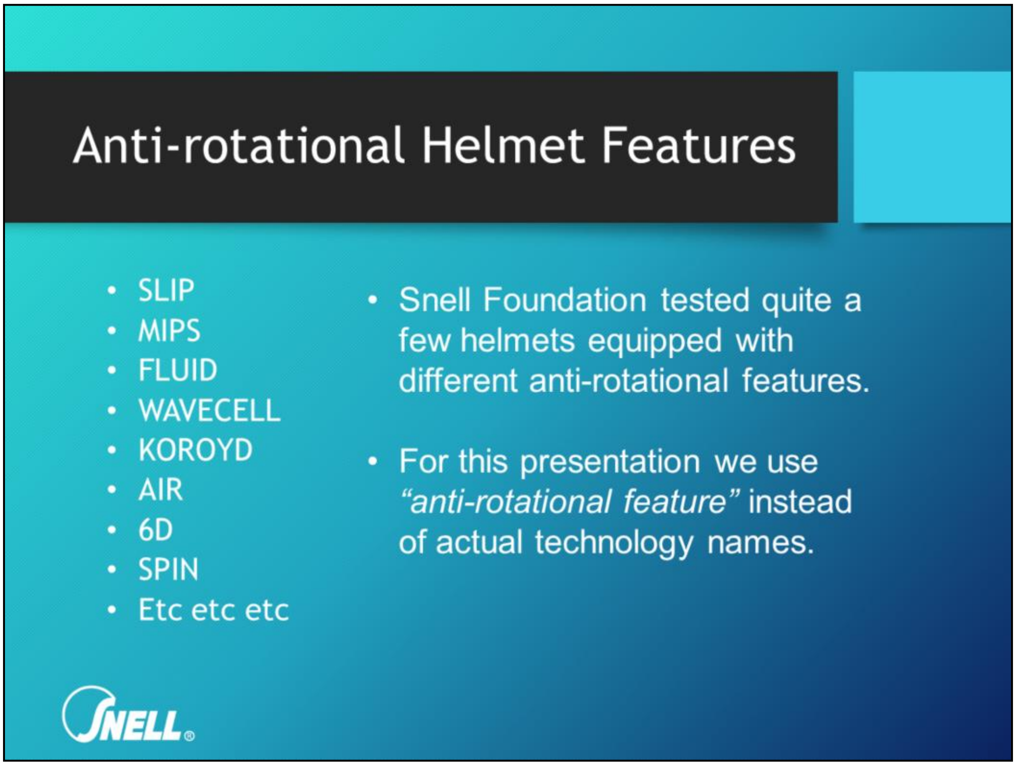
This long list of impact metrics as potential candidates for rotational injury criteria is a clear indication that there is a lack of consensus concerning the brain's tolerance for rotation. The range varies from good-old Peak translational acceleration to various Finite Element Strain/Stress models. The first organization to incorporate rotational response testing into their helmet standards is FIM (International Motorcycling Federation). They chose 4 criteria, limiting Peak Translational Acceleration, HIC, Peak Angular Acceleration, and BrIC. These values appear to have been based on the performance of the best of the currently available helmets in much the same way that Dr. Snively formulated test severities and criteria for Snell standards.



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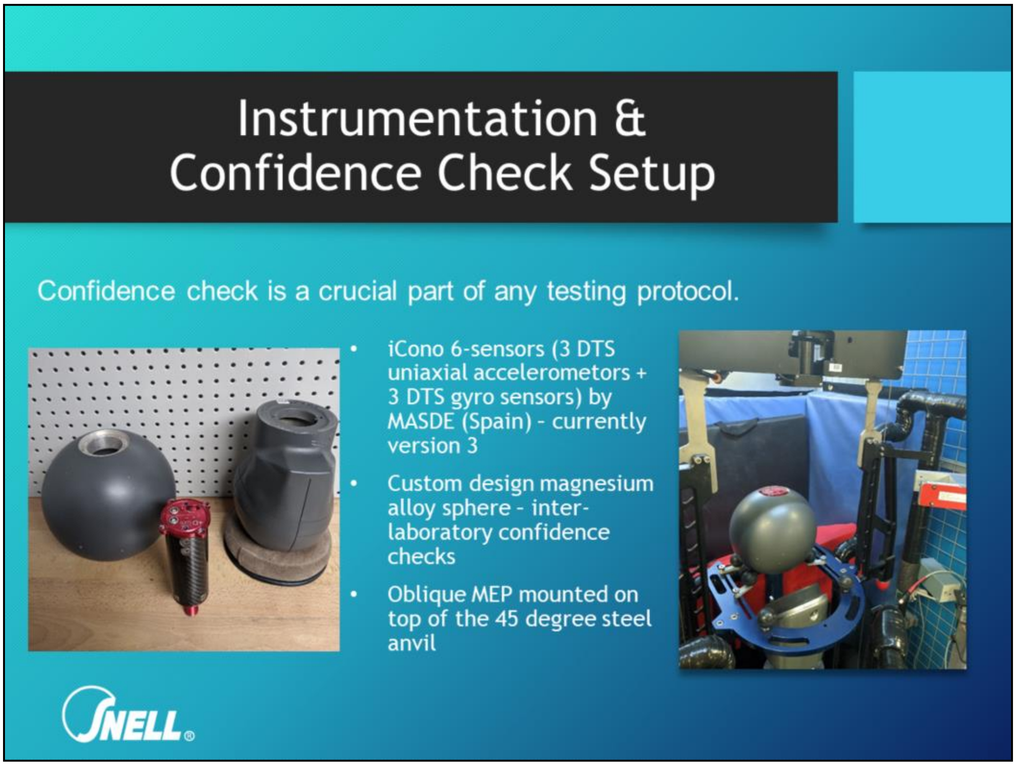
There are quite a few technologies available on the market which claim providing protective benefits involving oblique impacts. Interestingly enough the language used to market such technologies has changed dramatically since they became available. Early on, the claims were quite extravagant, along the lines of "this technology is up to 20 times more protective against concussions than conventional helmets." Currently, the language is more subdued, for example "this helmet is designed to be more effective than traditional helmets in protecting your head from injuries caused by certain accidents" or "reduction of rotational forces of at least 10%, compared to comparable helmets without this anti-rotational technology".

Snell has tested quite a few helmets equipped with different anti-rotational features. Some of these had been submitted for Snell certification and most did very well, no real surprise since most major manufacturers are familiar with Snell testing procedures and put their models through exhaustive testing before they're submitted. However, we were pleased to note that the particular anti-rotational features incorporated into these models did not add appreciably to their weight or silhouette. That is, except possibly for price, these anti-rotational helmets would be no less appealing to helmet users than comparable standard helmets.

Even so, testing to Snell standards did not really exercise these helmets' anti-rotational features. We turned to oblique impact procedures to see whether these anti-rotational features perform, if not to the extravagant claims made for injury risk reduction, at least to the more sober assurances regarding reduced rotational velocity and acceleration.



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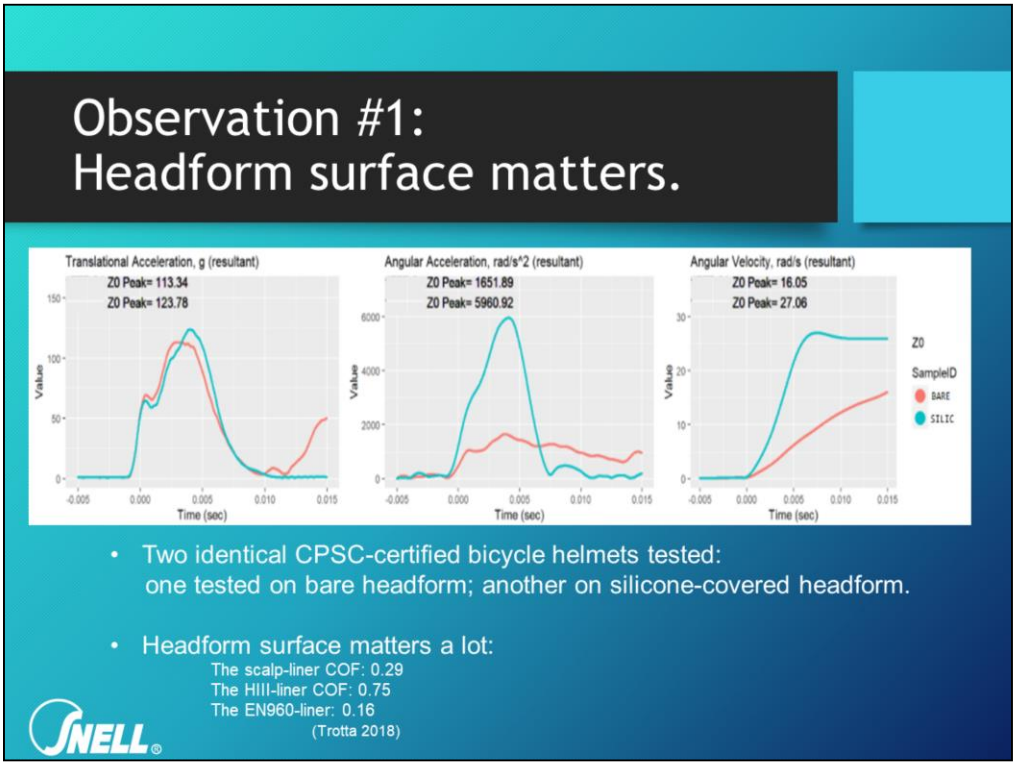
Oblique impact imposes a lot of complications that Snell's guided fall testing manages to avoid. In guided fall, the head form and helmet are constrained to a single axis, down and up; in oblique impact the helmet and head form must be free to move and to rotate in all three dimensions. Instead of a single accelerometer measuring impact shock, oblique impact demands three axes of translational acceleration and three axes of rotation. We went with the same package in current use for FIM certification testing. It's a compact device containing three translational accelerometers and three angular rate sensors along with on-board power, analog to digital conversion and data storage, This device docks firmly into standard test head forms and records and stores the complete mechanical response to an impact event which can then be downloaded and analyzed afterwards.

Most impact test protocols also call for a confidence check on the systems and instrumentation. In this effort, we employed a specially made magnesium sphere machined to accept the instrumentation package as well a Modular Elastomer Programmer (MEP) mounted obliquely. Oblique impact testing of the sphere against this MEP yields repeatable responses which can be compared day to day and month to month to demonstrate that the equipment and instrumentation continue to function in good order.



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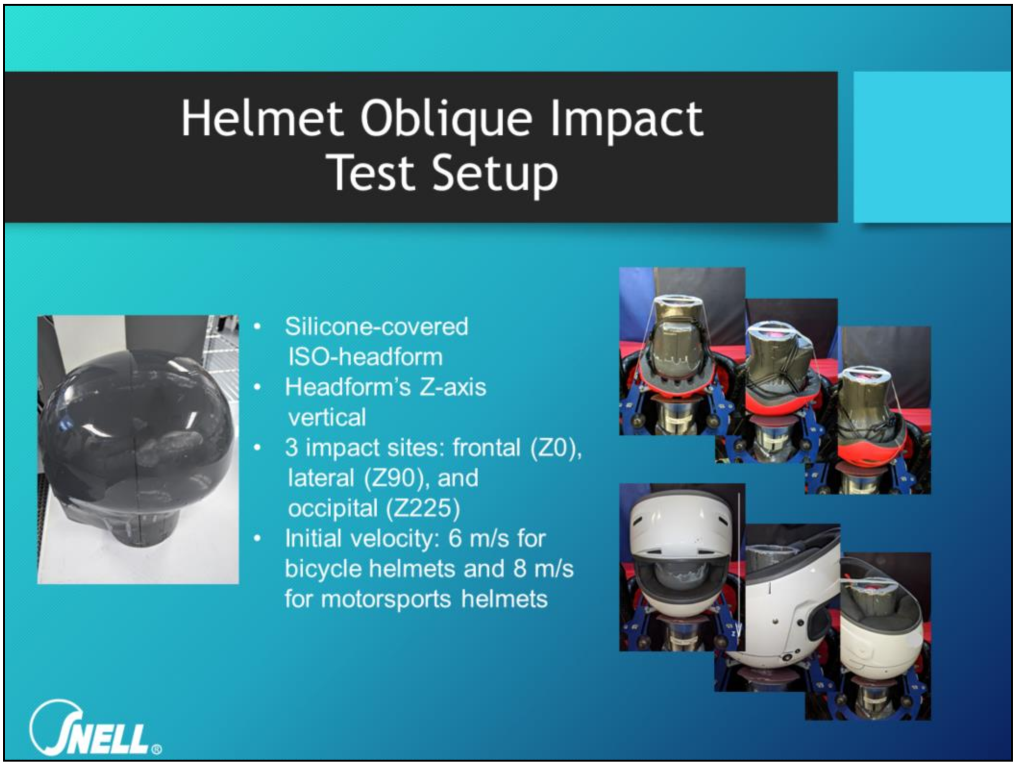
Most all the current anti-rotational innovations available in current helmets allow the wearer's head to slip relative to the impact surface. Some helmets include a layer of material over the shell which functions much like a banana peel allowing the helmet shell to slip easily along the roadway, others allow the helmet's impact liner to slip relative to the outer shell, still others allow one layer of the impact liner to slip relative to another layer while another allows a thin sheet of plastic in the crown of the helmet to slip along the impact liner's inner surface. All of these are intended to break the coupling between tangential forces applied to the helmet exterior and the forces applied by the helmet to the wearer's head, A remaining uncertainty, though, is the degree of coupling these systems might be called on to break. If the coupling that might be expected for actual human heads is already low, these anti-rotational innovations might be purposeless. And unless the coupling between a test head form and the helmet reliably reflects the coupling for helmet users, pronouncements based on laboratory testing may be meaningless.

The coupling for a particular test head form, the one associated with the Hybrid III neck, is appreciable thanks to its rubber "skin." Much of the claims currently made for anti-rotational helmets is based on tests with Hybrid III systems. However, the ISO head forms called out in Snell, ECE and FIM testing have smooth, low friction surfaces. FIM remedies this by calling for a thin, silicone layer to be applied to the head form surface which, reasonably, might standardize head forms across test laboratories.

One of the first oblique impact test series performed at Snell compared the response of untreated head form to that of head forms treated with this silicon material. The head forms were inserted into identical, major brand bicycle helmets and dropped at six meters per second onto the oblique anvil faced with 80 grit sand paper. The results showed a considerable reduction in angular acceleration with a corresponding change in angular velocity. There were also smaller differences in the translational acceleration magnitude.

It is apparent that the condition of the head form surface is a critical element. The silicone treatment is a plausible means of standardizing testing across laboratories but whether this treatment adequately reflects helmet performance in the field is another matter. There are some published studies on this topic, one study from 2018 measured the coupling between a cadaveric human head and a helmet, and compared the result to similar measures for a Hybrid III system and also for an ISO head form. The smooth surface of ISO head form had a coefficient of friction half that of the cadaver but the Hybrid III head form had a coefficient of friction two and a half times greater than the cadaver. (“Evaluation of the head-helmet sliding properties in an impact test” by Trotta, et al. in the Journal of Biomechanics, May 2018).

Further confounding this issue of the coupling between helmet users and helmets is hair or the lack of it and the use of bandannas and baseball caps under the helmet.



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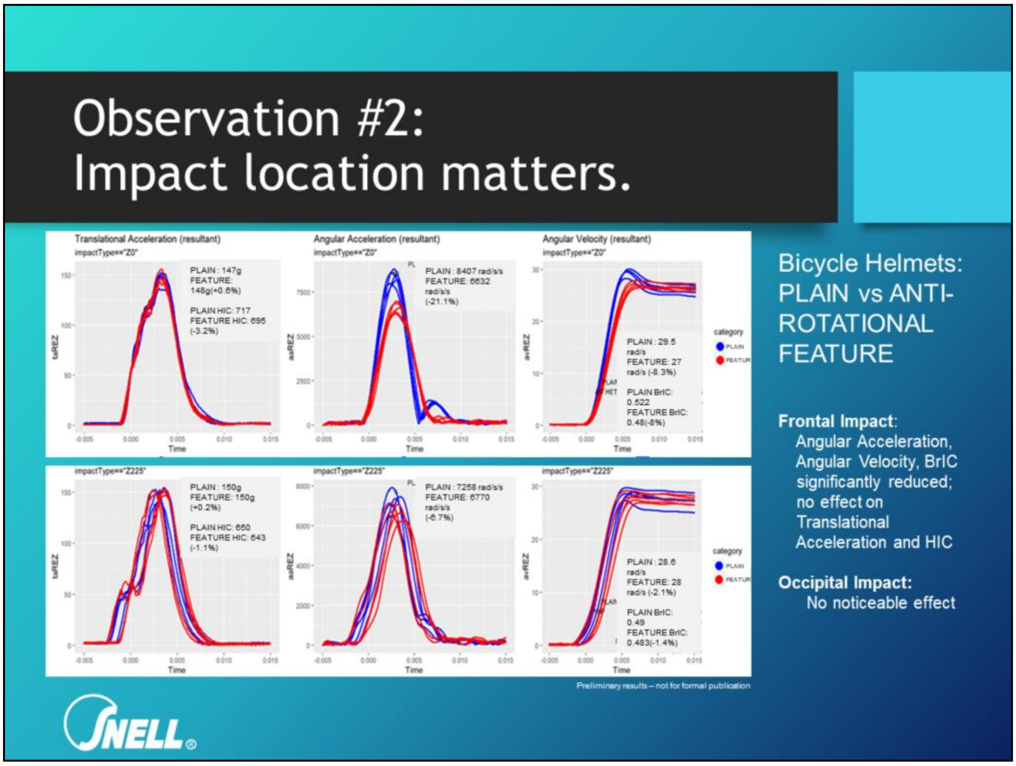
The next series were conducted according to the FIM protocol. The head forms were treated with silicone and each helmet was impacted three times according to diagrams in the FIM FRHPhe#1 standard; that is: with the head form Z axis pointing straight downward and the head form rotated about its Z axis first to strike the oblique anvil in the center of the brow, then rotated 90 degrees for a lateral strike and the 135 degrees for a strike roughly half-way between the helmet's rear and its left side. These impact sites appeared to be sufficiently spaced so that damage from previous impacts did not affect the results for later impacts.



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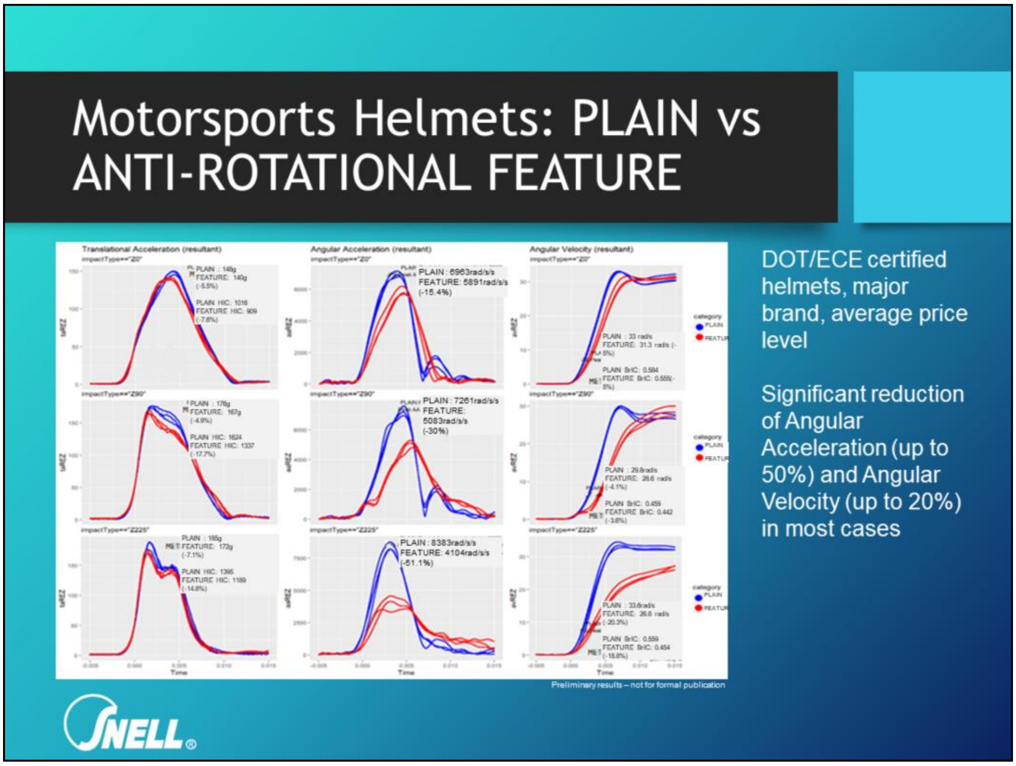
The first of these series compared results for bicycle helmets equipped with one of the popular anti-rotational innovations with similar, almost identical helmets without this feature. We noted a 20% reduction in peak angular acceleration for frontal impact although the results for angular velocity were remarkably similar. However, the results for the third site halfway between a rear and a lateral impact showed almost no difference at all.



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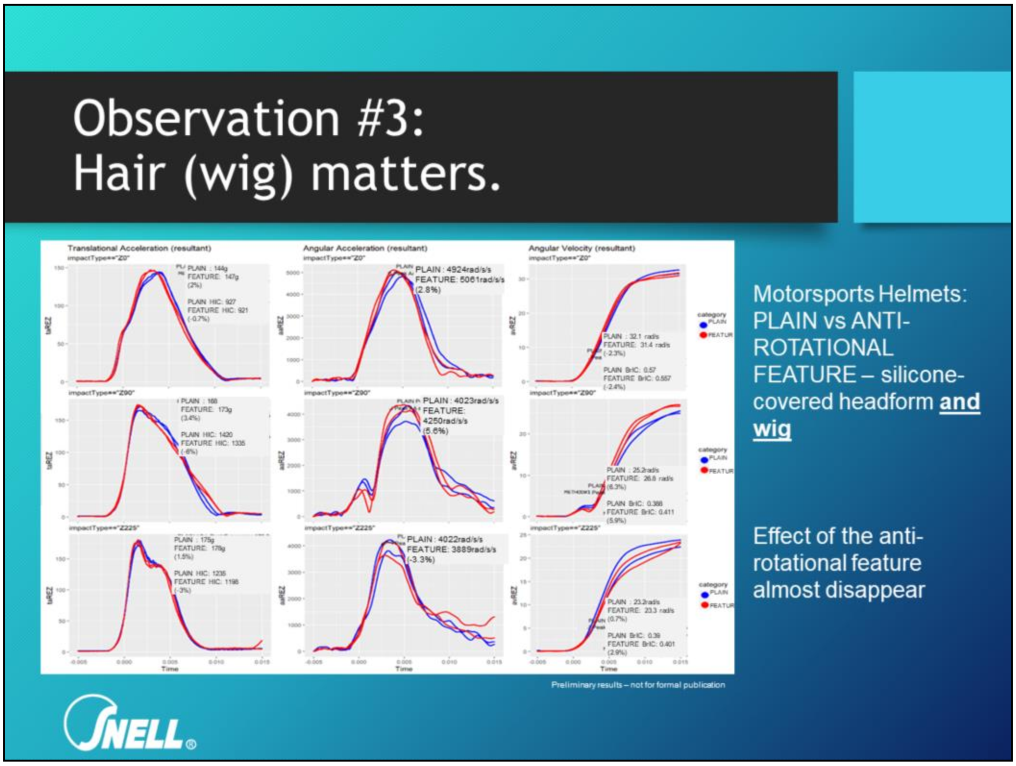
Motorcycle helmets performed a little differently. The anti-rotational feature yielded reductions in angular acceleration for all three impact sites, peak angular acceleration reduction was 15 to 50% with the greatest reduction for impacts at that third site half way between rear and lateral. The differences for peak angular velocity were almost nonexistent for frontal and lateral impact but the third site yielded an appreciable reduction in peak angular velocity as well as for peak angular acceleration.



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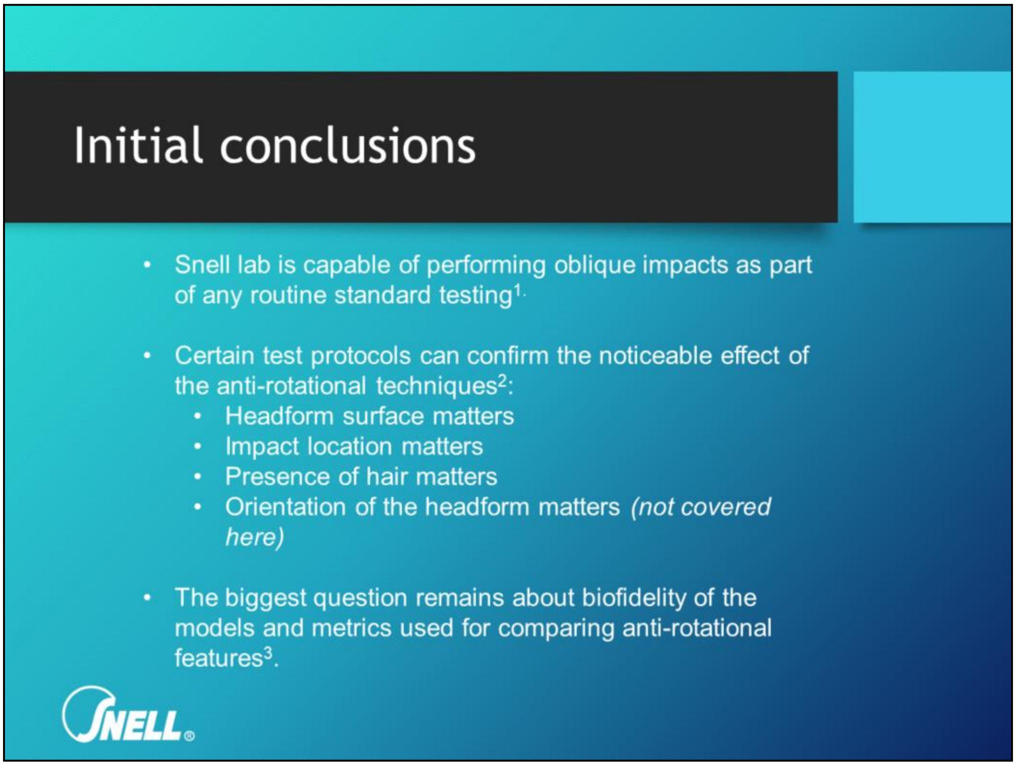
This next series was also conducted on helmets with and without the anti-rotational feature. The test head forms were all treated with silicone but also with a wig firmly in place atop the head form over the silicone coating. When the results were compared, there appeared to be no real difference. The wig broke the coupling between the head form and the helmet so completely that the anti-rotational feature had no effect on rotational acceleration or angular velocity in this series.



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1. We're confident that we can perform repeatable, reliable oblique impact testing should the requirement ever be included in testing for Snell certification, or if the service is ever added to our prototype testing service for Snell clients interested in pursuing FIM certification.

2. We have demonstrated that at least one anti-rotational innovation can change the response of helmets tested in oblique impact. However, we have also demonstrated that different test protocols which might reasonably simulate field conditions may reduce the effectiveness of this innovation.

3. Finally, although the testing has demonstrated that this anti-rotational feature does reduce peak angular velocity and peak angular acceleration for some tests conducted to FIM protocols, whether these findings bear on the protective performance of these features in real world crashes appears uncertain. Fortunately, helmets incorporating these features are already in use. Epidemiological studies of crash outcomes may one day tell us what we need to know.

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