

# **Motorcycle Fuel Tank Design and Pelvic Injury**

## **Summary of Research**

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In head-on, front-end collisions a rider is often “thrown directly forward against the high riding fuel tank, sustaining a direct blow to the anterior pelvis and soft tissues. The associated injuries can be devastating. Pelvic fractures, testicular rupture, urethral and bladder injuries, as well as other injuries may result from high velocity trauma. In addition to the pelvic injury, our patient had extensive scrotal damage with both testes severely traumatized and displaced out of the scrotum.”<sup>1</sup>

Now that we have the attention of our readers especially the men - let's take a look at the background and research related to the association between certain motorcycle design elements and injuries. The credit for bringing this issue to the attention of motorcyclists and motorcyclist safety professional goes to the late Wendy Moon<sup>2</sup> who wrote an article on the issue published in the July 2006 Motorcycle Consumer News.<sup>3</sup> Moon's article in MCN examines the tank design/groin issue in depth but also goes on to address how gas tank angle contributes to how - or even whether - the rider is ejected from the bike and how ejection is connected to the possibility of rotational brain injury. Moon's article also addresses how wheel design, stiffness of the front forks, frame construction material and design and handlebar location may contribute to rider injuries in the event of a crash.

While a definition of “motorcycle design” might include a wide variety of elements such as wheelbase, fork angle, frame construction, wheel rim construction material, engine configuration and operations components such as fuel supply, engine management, braking components, traction control and stability control, the available research connecting design and injury mainly focus on fuel tank design - specifically the angle and height of the fuel tank rise.

While SMARTER has discovered a 1976 conference report<sup>4</sup> that connects the width and height of the motorcycle tank to genitalia injury, the fundamental findings originate with the 1981 Hurt Report<sup>5</sup> which dedicates eight pages (220-228) to reporting data regarding groin injuries. The introduction to the groin injury section states “Early in the course of data collection, it became apparent that a substantial number of riders (and some passengers) complained of injury to the groin and often diffuse abdominal pain. In most instances this was associated with a characteristic pattern of damage to the motorcycle in which the top and sides at the back of the fuel tank was deformed inwards.”

Jim Ouellet and HH Hurt Jr. reported on this at the 1981 Proceedings of 25th Conference of the American Association for Automotive Medicine.<sup>6</sup> “During the typical frontal crash, the motorcycle rider slides forward into the gas tank, handlebars, steering head, etc., with the prospect of groin contact and injury. One hundred seventeen of the 900 riders (13%) sustained some type of groin injury, overwhelmingly in frontal collisions involving another vehicle. About 5% of those 117 involved severe injuries such as pubic bone fractures, separation of pubic symphysis, scrotal and bladder lacerations. Motorcycle parts, especially the fuel tank, accounted for about 90% of the injuries. Fuel tank shape affected groin injuries. Fuel tanks whose upper surface rose smoothly from seat level appeared to minimize injury, while tanks that rose steeply

in front of the seat increased injury. Also, riding posture appeared to affect groin injuries: leaning forward seemed to increase injury while upright and leaned-back postures seem to lessen injury severity.”

An in-depth examination of this issue came in 2002 with the publication of a Ph.D. dissertation by Jesse Wobrock.<sup>7</sup> Wobrock ran a series of simulations to investigate four basic scenarios: (1) three vertical gas tank angles (20, 55, and 90 degrees above horizontal), (2) two vertical handlebar positions (0 inches above the original location, and a 6 inch vertical extension), (3) the presence or absence of a windshield and (4) change in Delta-V (10 mph, 20 mph, 30 mph). His main finding was an exponential increase in both probable pelvic injuries and severity as the height and steepness of the rear of a motorcycle’s gas tank angle in front of the rider increases. Wobrock presented a summary his research as *Pelvic Injury Potential and Motorcycle Gas Tanks*<sup>8</sup> at the 2006 International Research Council on Biomechanics of Injury conference.

The 2003 article *Crotch rocket pelvic fractures*<sup>1</sup> from which the quote at the opening of this article highlights, points to the design of the race track inspired sport bike as the shape that is the cause of these types of injuries and the concern to this point in the research development has been for injuries suffered by the driver/operator of the motorcycle. However, a 2007 article titled *A two-rider motorcycle accident involving injuries around groin area in both the driver and the passenger*<sup>9</sup> published in *Legal Medicine* reveals that passengers can also suffer from injuries around the groin area.

A more recent piece of research seems to through a “monkey wrench” into the works. *Pelvic Injury Potential and Motorcycle Gas Tanks*<sup>10</sup>, a paper presented at the 2014 International Research Council on Biomechanics of Injury conference, confirms the previous research regarding (1) that rider contact with the motorcycle fuel tank is a major cause of pelvic injury in motorcycle crashes and (2) these predominantly occur in frontal or oblique collision configurations. However, this study found it was riders of cruisers who were more likely to sustain a pelvic injury than other motorcycle types. According to the authors this appears to contradict the relationship between the petrol tank angle and level of pelvic loading reported by earlier research as cruisers have a more gradual incline. The authors explain this contradiction by stating “these injuries likely represents two different mechanisms of injury associated with petrol tank contact. Pelvic injury in cruiser riders may be dependent on other fuel tank dimensions and/or rider posture, with the legs stretched out and the rider upright instead of leaning forward over the fuel tank.”

The research seems clear in that there is a connection between motorcycle fuel tank design, riding posture and groin injury. The authors of a 2016 study titled *Motorcycle Fuel Tanks and Pelvic Fractures: A Motorcycle Fuel Tank Syndrome*<sup>11</sup> aimed to investigate the mechanisms involved in pelvic injuries to crashed motorcyclists conclude (1) the most frequent cause of pelvic injuries in crashed motorcyclists was due to contact with the motorcycle fuel tank and (2) improvements in the design of crashworthy motorcycle fuel tanks appear to be required.

Jon DelVecchio, has taken this available research information and developed what he calls *Motorcycle Crash Rating Tool*<sup>12</sup> DelVecchio says “Riding is risky. Every serious rider knows that. But many don’t understand exactly what designs can be the most dangerous in a frontal

collision (the most common multi-vehicle crash type). Until the manufacturers take notice and build us safer designs, riders can use this rating tool to make better choices or simply be informed.”

1. *Crotch Rocket Pelvic Fractures*. Conor Hurson, Denis Collins, John P McElwain. *Injury Extra*, Volume 35, Issue 2, February 2004, Pages 17–19.
2. Wendy Moon was a staunch supporter of TEAM OREGON and outspoken critic of the Motorcycle Safety Foundation (MSF) who died suddenly of a heart attack on January 11, 2011. Most of the motorcycle safety community knew Wendy as Moonrider, author of the thoughtful, provocative and well-researched blog she established on Journalspace in 2005. She was unwavering in following her motto "Holding Powerful Interests Accountable".
3. *Dangerous Designs? Read this, and you'll never look at a motorcycle the same way again*. *Motorcycle Consumer News*, Volume 37, Number 7, July 2006, Pages 24-29.
4. *Injury Mechanisms and Motorcycle Design*, PV Hight, AW Siegel, AW Nahum. Conference proceedings International Research Council on Biomechanics of Injury, 1976.
5. *Motorcycle Accident Cause Factors and Identification of Countermeasures Volume I: Technical Report*. 1981. Access at <http://www.smarter-usa.org/research/crash-studies/>
6. *Groin Injuries in Motorcycle Accidents*. Ouellet JV & Hurt HH Jr., Proceedings of 25<sup>th</sup> Conference of the American Association for Automotive Medicine, San Francisco, CA 1981.
7. *MADYMO Simulation, Reconstruction, and Biomechanical Analysis of Motorcycle Crashes*. J.L. Wobrock, Ph.D. Dissertation, University of California, Los Angeles, 2002.
8. *Pelvic Injury Potential and Motorcycle Gas Tanks*. Jesse L. Wobrock. Paper presented at the International Research Council on Biomechanics of Injury conference. 2006.
9. *A Two-rider Motorcycle Accident Involving Injuries around Groin Area in Both the Driver and the Passenger*. Yoko Ihama, Chiaki Fuke, Tetsuji Miyazaki. Department of Legal Medicine, School of Medicine, University of the Ryukyus, 207 Uehara, Nishihara, Okinawa 903-0215, Japan. *Legal Medicine*, September, 2007.
10. *Pelvic Injury Potential and Motorcycle Gas Tanks*. Lauren Meredith, Matthew Baldock, Michael Fitzharris, Julie Brown. Paper presented at the International Research Council on Biomechanics of Injury conference. 2014.
11. *Motorcycle Fuel Tanks and Pelvic Fractures: A Motorcycle Fuel Tank Syndrome*. Lauren Meredith, Matthew Baldock, Michael Fitzharris, Johan Duflou, Ross Dal Nevo, Michael Griffiths. *Traffic Injury Prevention*, Volume 17, 2016 - Issue 6, Pages 644-649
12. *Street Skills LLC*. Jon DeVecchio, <http://streetskills.net/motorcycle-crash-ratings/>.