

Design of a Double-Barrel Syringe for Sports Medicine

(Technical Paper)

The Struggle over Athletes' Safety

(STS Paper)

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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General research problem: Player safety in sports

How are improvements to athletes' health and safety being pursued?

Organized sports began in 776 BCE with the first Olympic games in Greece. Athletics have a risk of injuries with ranging severity. Recent findings identified variability in injury rate based on the sport and play intensity (Ciro et al., 2007). Injuries are present at all levels of sports, but are best recorded at professional levels, where in the National Football League (NFL) there were 931 and 800 injuries in 2018 and 2019 respectively (Baker et al., 2021). Injuries in sports impact muscular, skeletal, and neurological systems often needing moderate treatment, but sometimes requiring extensive procedures or precautions. Treatments are present for many injuries and take different forms (e.g., surgery or injection), but are limited in patient comfort or recovery time, so improvements are being pursued. Other injuries, like concussions, have less developed treatments and are instead managed to mitigate lasting impacts and improve comfort as the body heals itself (Wright, 2014). Concussions occur in sports, especially American football, as a result of head trauma and are the subject of research identifying the associated risk of cognitive impairment and mental health problems (Manley et al., 2017). Efforts are being made to improve treatment methods and risk mitigating precautions to ensure health and longevity of athletes.

Design of a Double-Barrel Syringe for Sports Medicine

How can a syringe be designed to improve efficiency and patient outcomes of sports medicine injections?

The project is in the Biomedical Engineering Department through Capstone under the advisement of Dr. Jeremy B. Kent, a practicing physician in the Family Medicine Department,

and Dr. Timothy Allen, a professor of Biomedical Engineering. Project collaborators are Grace Park, Rohan Chandra, and Teodor Calin.

Ultrasound-guided injections are commonly used to treat injuries to the hip, shoulder, hand, knee, and other joints and often involve administration of multiple solutions (ex. anesthetics and steroids) (Daniels et al., 2018). Many of these injections are done on athletes, coining the term sports ultrasound in 2015 for diagnosis and treatment in sports medicine (Daniels et al., 2018). Ultrasound technology used with a syringe allows clinicians to achieve proper injection location and depth, which improves accuracy and patient outcomes compared to unguided injection (Ucuncu et al., 2009) (Aly et al., 2015). Despite increased precision with imaging, patient discomfort and physician administration difficulty can be improved.

Current sports injections require a single-barreled syringe in one hand and a hand-held ultrasound machine in the other (Sibbitt et al., 2012). A needle is inserted into the patient with the first solution in the single-barrel syringe, then after injecting the first fluid the needle remains in the patient while the syringe is unscrewed and replaced by a new one containing the second solution. Multiple syringes and needles are required for the injection of disparate fluids, which creates greater patient discomfort because more needle insertions and movement occur. Trouble is caused for the physician who must shuffle multiple items while retaining ultrasound view. Current methods leave room for improvement with a design that allows injection of two separate fluids by a single syringe.

The goal is to create and prototype a design that functionally injects two fluids without leaking or mixing and adheres to parameters set by clinical professionals. Identification and assessment of marketability through interest exploration in the relevant medical community is the secondary goal. Project constraints have been placed under advisement for practical and

functional purposes. These include no fluid leaking, minimal solution mixing, one-handed use, stable luer lock interfaces, and fluid volume accuracy. Dimensional and weight constraints exist for hand compatibility.

The research problem will be addressed through design in Autodesk Fusion360 and prototyping by 3D printing. The prototype will be evaluated iteratively with each version to reveal needed improvements. The fluid seal will be visually inspected by drawing and injecting over a water container. The interference of edges to fluid flow will be evaluated by Fusion360 force simulations. Solution mixing will be evaluated using dye to color a fluid and determining the appearance of dye in the other chamber. Physician satisfaction for one handed usability of functional designs will be tested by presentation to several clinicians and gathering of an approval rating.

A successful project will yield a functioning prototype of a syringe able to inject two solutions disparately without leaking and while meeting design specifications. This prototype will also have gained a 90% minimum approval rating from surveyed clinicians for one handed operation and comfort. Success will matter because the device will prevent excess steps for guided injection and needle movement. This will reduce patient discomfort and clinician demand for the procedure. Future steps for the project would involve patenting, market analysis, partnership for production, and sales generation.

The Struggle over Athletes' Safety

How do advocates of player safety in sports advance their agendas?

How can sports be made safer and injuries avoided? Since athletic competition began, injuries have accompanied ranging in severity from minor (e.g., bruises or scratches) to severe

(e.g., breaks or contusions). Head trauma is a common tackling related injury in sports and is a known cause of concussions. Because researchers have traced cognitive impairments and mental illness to concussions, greater research attention has been committed to injury prevention (Manley et al., 2017). A 412% increase in the phrase “Player Safety” has been seen between 2000 and 2018 with Google Books Ngram Viewer showing a 0.0000001771% and 0.0000007305% citation rate respectively (Google, 2021).

Researchers have investigated efforts to prevent and mitigate musculoskeletal injury in youth sports and elite competition; proposals have included limiting practice contact and rules modifications (Emery & Pasanen, 2019). Benson et al. (2013) have found that rules changes can prevent concussions and other sports injuries. Citing the NHL’s obligation to promote and players’ health and wellbeing, Caron and Bloom (2015) have proposed rules changes and training.

Major Participants

Some players favor stronger regulations to better protect players. NFL quarterback Tom Brady has called for better leg protection, saying the league “should change some of those rules with defenseless receivers... everyone else has their legs protected in the NFL” (Fitzgerald, 2017). Rules changes have already protected some players, including quarterbacks and linemen, from low hits.

Some NFL players, including Richard Sherman, Lorenzo Alexander, and Josh Norman oppose the current and proposed regulations, contending they unduly constrain defensive play. Commenting on a new NFL targeting rule in 2018, Alexander said: “It is football at the end of the day. There are going to be injuries that you can’t avoid. You can’t legislate everything out”

(Freeman, 2018). Players who criticize such regulations may also wish to avoid fines or penalties.

To some fans, enforcement of safety regulations compromises the game. Ev, of Barstool Sports, commented “with the direction that football and safety are going in the rule itself is obviously not going anywhere, but there needs to be some kind of change” (Ev, 2021). Ev was objecting to the expulsion of four players in one game under targeting violations. In targeting contact is made with a lowered helmet. Such maneuvers are hazardous, risking concussions (SEC Sports, 2019).

Dr. Arthur De Luigi, a sports medicine doctor, has said “I think that the NFL, and subsequently the NCAA’s regulations for player safety are paramount” (Daniels, 2014). Like many other sports medicine professionals, De Luigi values safety and favors rules that protect players, especially their heads and necks. This group values the health of players above other factors and seeks to promote rules to protect the players from injury.

The NFL notes that it has “supported critical innovation in helmet design” for safer play (NFL, 2021). To the NFL revenue is paramount. To protect revenue, the league must balance the entertainment value of the game against player safety.

References

- Aly, A., Sathish, R., & Ashworth, N. (2015). Ultrasound-guided shoulder girdle injections are more accurate and more effective than landmark-guided injections: a systematic review and meta-analysis. *British Journal of Sports Medicine*, 49(16), 1042-1049.
- Baker, H. P., Pirkle, S., Cahill, M., Reddy, M., Portney, D., & Athiviraham, A. (2021). The injury rate in national football league players increased following cancellation of preseason games because of COVID-19. *Arthroscopy, Sports Medicine, and Rehabilitation*, 3(4), e1147-e1154. ScienceDirect.
- Benson, B. W., McIntosh, A. S., Maddocks, D., Herring, S. A., Raftery, M., & Dvorak, J. (2013). What are the most effective risk-reduction strategies in sport concussion? *British Journal of Sports Medicine*, 47(5), 321-326.
- Caron, J. G. & Bloom, G. A. (2015). Ethical Issues Surrounding Concussions and Player Safety in Professional Ice Hockey. *Neuroethics*, 8(1), 5-13. Web of Science.
- Ciro, J. A., Rodriguez, M. P., Arango, V. E., Giraldo, S. P., & Ching, I. C. (2007). Sports Injuries. *IATREIA*, 20(2), 167-177. Web of Science.
- Daniels, D. (2014, September 29). Eric LeGrand praises NFL safety measures as he advocates for spinal injury patients. *The Washington Times*.
<https://www.washingtontimes.com/news/2014/sep/29/eric-legrand-praises-nfl-safety-measures-he-advoca/>.
- Daniels, E. W., Cole, D., Jacobs, B., & Phillips, S. F. (2018). Existing Evidence on Ultrasound-Guided Injections in Sports Medicine. *Orthopaedic Journal of Sports Medicine*, 6(2), 2325967118756576.
- Echlin, P. S., Tator, C. H., Cusimano, M. D., Cantu, R. C., Taunton, J. E., Upshur, R. E. G., Hall, C. R., Johnson, A. M., Forwell, L. A., & Skopelja, E. N. (2010). A prospective study of physician-observed concussions during junior ice hockey: implications for incidence rates, *Neurosurgical Focus FOC*, 29(5), E4. Journal of Neurosurgery.
- Emery, C. A. & Pasanen, K. (2019). Current trends in sport injury prevention. *Best Practice & Research in Clinical Rheumatology*, 33(1), 3-15. Web of Science.
- Ev, B. (2021, Sep. 7). College football needs to change their targeting Rules ASAP. *Barstool Sports*. <https://www.barstoolsports.com/blog/3382450/college-football-needs-to-change-their-targeting-rules-asap>.
- Fitzgerald, M. (2017, Oct. 1). Tom Brady advocates for rule changes to Protect knees of Defenseless Receivers. *Bleacher Report*. <https://bleacherreport.com/articles/2595245-tom-brady-advocates-for-rule-changes-to-protect-knees-of-defenseless-receivers>.

- Freeman, M. (2018, Mar. 29). NFL's New Targeting Rule is Going to be a Total Disaster. *Bleacher Report*. <https://bleacherreport.com/articles/2767037-nfls-new-targeting-rule-is-going-to-be-a-total-disaster>
- Google. (2021, Oct. 31). Player Safety. *Google Books Ngram Viewer*. https://books.google.com/ngrams/graph?content=player+safety&year_start=1800&year_end=2019&corpus=26&smoothing=3&direct_url=t1%3B%2Cplayer%20safety%3B%2Cc0#t1%3B%2Cplayer%20safety%3B%2Cc1
- Manley, G., Gardner, A. J., Schneider, K. J., Guskiewicz, K. M., Bailes, J., Cantu, R. C., Castellani, R. J., Turner, M., Jordan, B. D., Randolph, C., Dvorak, J., Hayden, K. A., Tator, C. H., McCrory, P., & Iverson, G. L. (2017). A systematic review of potential long-term effects of sport-related concussion. *British Journal of Sports Medicine*, 51(12), 969-977.
- NFL. (2021, Apr. 20). *NFL, NFLPA release 2021 Helmet Laboratory Testing Performance Results*. NFL.com. <https://www.nfl.com/playerhealthandsafety/resources/press-releases/nfl-nflpa-release-2021-helmet-laboratory-testing-performance-results>.
- SEC Sports. (2019, Nov. 1). What is targeting? <https://www.secsports.com/article/27981840/what-targeting>
- Sibbitt, W. L., Kettwich, L. G., Band, P. A., Chavez-Chiang, N. R., DeLea, S. L., Haseler, L. J., & Bankhurst, A. D. (2012). Does ultrasound guidance improve the outcomes of arthrocentesis and corticosteroid injection of the knee?. *Scandinavian Journal of Rheumatology*, 41(1), 66-72. Taylor & Francis Online.
- Ucuncu, F., Capkin, E., Karkucak, M., Ozden, G., Cakirbay, H., Tosun, M., & Guler, M. (2009). A comparison of the effectiveness of landmark-guided injections and ultrasonography guided injections for shoulder pain. *The Clinical Journal of Pain*, 25(9), 786-789.
- Wright, J. M. (2014). Medical Treatment of Concussion. *Seminars in Speech and Language*, 35(3), 155-158. Web of Science.