# Analysis of Traumatic Brain Injuries Using Kinovea and the University College Dublin Brain Trauma Model

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## Introduction

- Traumatic brain injuries, or TBIs, can have detrimental effects like memory loss or even death.
- Many reported TBIs occur during contact sports, like American Football.
- Though much research has gone into the neuropsychological effects of sports-related TBIs, little research has gone into the mechanics of these injuries and how to prevent them.
- Overall, this project is an example of a methodology for performing forensic reconstructions of sports-related head impacts to improve helmet testing and elucidate the mechanics of TBIs.

## Results

Table 1a: Kinovea Results- Linear Impact Velocities

| | Linear Impact Velocity Components | | | | | |
|---|---|---|---|---|---|---|
| | Vx (m/s) | Difference | Vy (m/s) | Difference | Vz (m/s) | Difference |
| Jack Riewoldt | -0.97 | 288% | -4.73 | -21% | 0 | 0% |
| Aidan Corr | 0 | 0% | -9.58 | 6% | -5.8 | -314% |
| Tiernan O'Halloran | -1.78 | 212% | 1.27 | -124% | -0.76 | -138% |
| Willie Le Roux | -0.87 | N/A | 2.31 | -151% | -3.98 | -320% |
| Leonardo Senatore | -0.58 | -23% | -5.6 | -17% | 1.00 | -20% |

Table 1b: Kinovea Results- Angular Impact Velocities

| | Angular Impact Velocity Components | | | | | |
|---|---|---|---|---|---|---|
| | Wx (rad/s) | Difference | Wy (rad/s) | Difference | Wz (rad/s) | Difference |
| Jack Riewoldt | 0 | 0% | 0 | 0% | -4.03 | -4% |
| Aidan Corr | 21.13 | 34% | 0 | 0% | 0 | 0% |
| Tiernan O'Halloran | -1.76 | -37% | -0.97 | -62% | -4.42 | -47% |
| Willie Le Roux | 0.5 | -167% | -1.31 | -285% | -0.77 | -144% |
| Leonardo Senatore | -4.53 | -17% | 0 | -100% | -3.27 | 16% |

Table 2: UCDBTM Results

| Case | Parameter | Protected | Difference | Unprotected | Difference | Protection Factor |
|---|---|---|---|---|---|---|
| 1a | Von Mises stress (kPa) | 7.854 | -11.15% | 10.76 | -13.23% | -27.01% |
| | Max Principal strain (%) | 15.83 | -6.88% | 19.6 | -18.33% | -19.23% |
| 1b | Von Mises stress (kPa) | 6 | -1.82% | 8.611 | -23.80% | -30.32% |
| | Max Principal strain (%) | 12.44 | 3.67% | 15.17 | -27.76% | -18.00% |
| 2a | Von Mises stress (kPa) | 7.658 | 8.32% | 12.88 | -8.65% | -40.54% |
| | Max Principal strain (%) | 13.87 | 5.08% | 23.59 | -14.22% | -41/20% |
| 2b | Von Mises stress (kPa) | 6.65 | 10.47% | 10.19 | -15.79% | -34.74% |
| | Max Principal strain (%) | 13.12 | -30.21% | 20.29 | -15.10% | -35.34% |
| 3 | Von Mises stress (kPa) | 8.22 | -1.32% | 14.3 | -8.33% | -42.52% |
| | Max Principal strain (%) | 15.86 | 0.38% | 26.41 | -7.98% | -39.95% |

- Tables 1a and 1b show the head impact velocities from Phase 1 and their differences to Mr. Boland's results.
- 11 out of 30 results were found to have a difference of 100% or over.
- These large differences were probably due to differences in methodology, as the degree of the polynomial fitted curve and path adjustments were manually set.
- Visual comparison of velocity plots to Mr. Boland's showed similar data points but sometimes differing degrees of the polynomial curve; example is shown in Figure 2,
- Overall, these results may not be used to validate Mr. Boland's Kinovea results, as there were several large dissimilarities in head impact velocity.

- Table 2 shows the maximum Von Mises Stress and maximum principal strain for the five orientation cases from Phase 2, their difference to the validated results, and the protection factor.
- Though most values were similar, it was found that the parts of the brain used in this study were different from the validated data's methodology. Thus, the UCDBTM results could not be validated.
- Results show that the brain in the protected cases experience less Von Mises stress and principal strain than the unprotected cases for all orientations.

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## Methodology

Phase 1: Kinovea

- Five cases of rugby head impacts were studied: Jack Riewoldt, Aidan Corr, Tiernan O'Halloran, Willie Le Roux, and Leonardo Senatore.
- Kinovea is the video analysis software used to track players' heads from a designated starting point to the point of impact. The position of the path was sometimes adjusted manually.
- Using Matlab code, the data from Kinovea was converted into linear and angular velocities and a polynomial trend curve was fitted, the degree of which was chosen qualitatively.
- The end velocities characterize the mechanics of the head impacts.
- These results were compared to Robert Boland's results.

Phase 2: University College Dublin Brain Trauma Model (UCDBTM)

- The University College Dublin Brain Trauma Model V1 (UCDBTM) is a 3-D finite element model of the head used to measure the stresses and strains in the brain due to head impacts. These values can indicate the degree of injury.
- A set of five different orientations were used, as shown in Figure 1; each test case was performed with a protected (helmeted) and unprotected version.
- These output results were compared to the validated results.
- Additionally, a protection factor was calculated as the percent difference of stress and strain between the protected and unprotected cases.

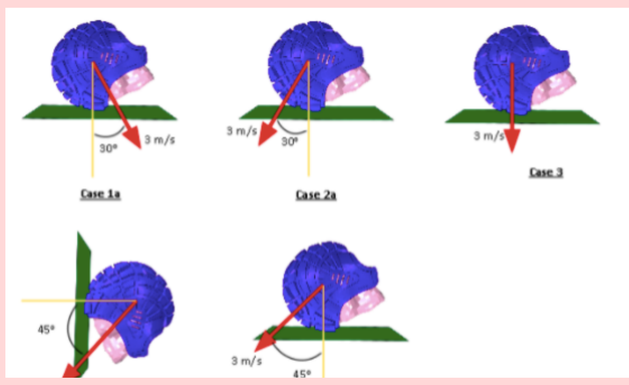


**Figure 1.** Various orientation test cases used on the UCDBTM.

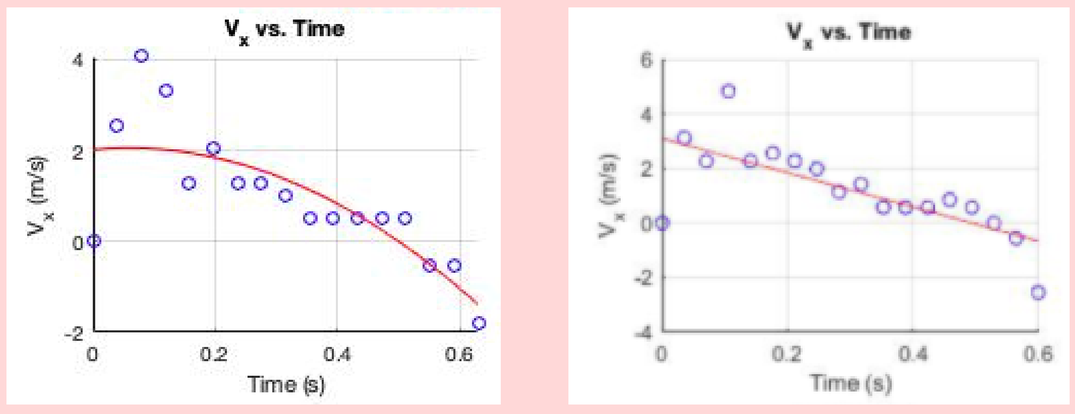


**Figure 2.** Vx graph for Willie Le Roux. On the left is my graph; on the right is Mr. Boland's.

## Conclusions and Future Work

- Kinovea data points were consistent to Mr. Boland's but the head impact velocities were dissimilar, with an average difference of -48% and standard deviation of 127%.
- UCDBTM results show that wearing the helmet lessens injury to the brain due to head impacts, as the protection factor average and standard deviation for stress was, respectively, -35.03% and 7% and for strain is -30.74% and 11%.
- However, UCDBTM results were unable to be validated due to extenuating circumstances.

- Kinovea results may be made more consistent through creating a quantitative method for choosing the degree of the polynomial trend curve.
- By applying the mechanics of real-life sports-related head impacts, the actual degree of injury to the brain can be found. **This methodology could be used to test helmets or predict neuropsychological effects of TBIs.**