

CTE In Football

Zayd Tanbour

Michigan Islamic Academy

### Abstract

This research paper discusses the development of neurodegenerative disease CTE (Chronic Traumatic Encephalopathy) in football players around the world and how today's football helmets are not protecting players. It discusses the complex science behind the disease and how deadly it can be if not discovered. Also, this paper mentions how using a gyroscopic mechanism can be used to redesign today's football helmets to better protect the brain. The game of football will continue to be played by millions of players from children to adults, and this paper discusses a way to provide players a safer experience that will lead them to a healthier life.

## CTE in Football

When it comes to football, many overlook the risks of playing the game. As fans sit down to watch Sunday Night Football, they cheer for their team and put their hands up when their favorite player hits the opponent, but do they ever think about how risky that hit was? Around 99 percent of former NFL (National Football League) players have been diagnosed with chronic traumatic encephalopathy (CTE) (Ruth et al., 2017). Unfortunately, this brain disease is widespread at all levels of football. Approximately 21 percent of high school football players and 87 percent of college football players have been found to have traces of CTE in their brains (Ruth et al., 2017). Diseases like CTE tend to be undermined. To add to this, CTE can only be diagnosed post-death (“What Is CTE”, 2019). Remodeling football helmets to better protect the head of the human body can prevent the disastrous effects CTE has on football players of all different ages. The combination of both engineering simulation processes and knowledge of neuroscience can reduce the number of CTE cases in football players.

To reduce CTE in both high school and NFL players, football helmets need to be redesigned. Modern football helmets do not protect the head enough to sustain straight-on head collisions and lack this important protection feature. Most modern tech helmets that have been redesigned for protection are either too expensive or are not approved yet to be sold to NFL teams (Skiver, 2017). The most popular and revolutionary safe helmet, the ZERO1, costs around \$1,500 per NFL player (Skiver, 2017). An affordable high-tech helmet that cushions the head and protects it from the hardest of hits can be made using a gyroscopic mechanism to build a net of springs and cushions in the helmet to help the brain stay stable and not rattle inside the

player's head. With the helmet being affordable and protective, football players all around the world can play the game worry-free.

CTE - Chronic Traumatic Encephalopathy - is a progressive degenerative disease that affects the brain of those who suffer repeated hits to the brain (Fesharaki-Zadeh, 2019). It is widespread among contact-sport athletes such as boxers, football players, and rugby players. It is a condition or type of brain damage that persistently impacts the cranium of a person over a period of years or decades. Over time, it gradually deteriorates an athlete's brain, causing the brain to lose mass. While there are areas in the brain that experience atrophy, deterioration, some particular areas are still prone to enlargement (Fesharaki-Zadeh, 2019).

CTE was first described as "punch drunk syndrome" in 1928 by Dr. Harrison Martland ("What Is CTE", 2019). He had noticed this in boxers and as the next 75 years progressed, doctors began noticing these same symptoms in victims of brain trauma and it became more common in boxers ("What Is CTE", 2019). Even though doctors noticed that there was a disease in the brain that had not been discovered yet, fewer than 50 cases were actually confirmed over those 75 years ("What Is CTE", 2019). In 2005, Dr. Bennet Omalu was the first person to diagnose CTE and publish evidence for it. His patient was former Pittsburgh Steeler Mike Webster ("What Is CTE", 2019).

Though it takes many years for symptoms to show, CTE only has four stages, each lasting many years. CTE and other diseases such as Alzheimer's are the results of an increased presence of tau in the brain. Tau is a microtubule-associated protein that is lined up along nerve cells in the brain. Nerve cells are made up of neurons, which are the basic building units of the brain ("The Science of", 2018). Although many think this protein is harmful to the brain, it is

very necessary and helps stabilize these nerve cells in its natural amount. The damage of CTE occurs when too much tau is produced, eventually clogging the brain and its blood vessels (Fesharaki-Zadeh, 2019). As stated, excessive tau build-up is the cause of other diseases but the pattern that it forms in the brain is specific to CTE. This specific shape or pattern is in the shape of neurofibrillary tangles (NFTs) (Fesharaki-Zadeh, 2019). Over the years, doctors began to notice this pattern in brain scans and that is essentially how they were able to diagnose this disease. Unfortunately, as of now, doctors can only diagnose CTE post-death (“What Is CTE”, 2019). Due to this setback, doctors must be able to diagnose athletes based on symptoms and behavioral activity.

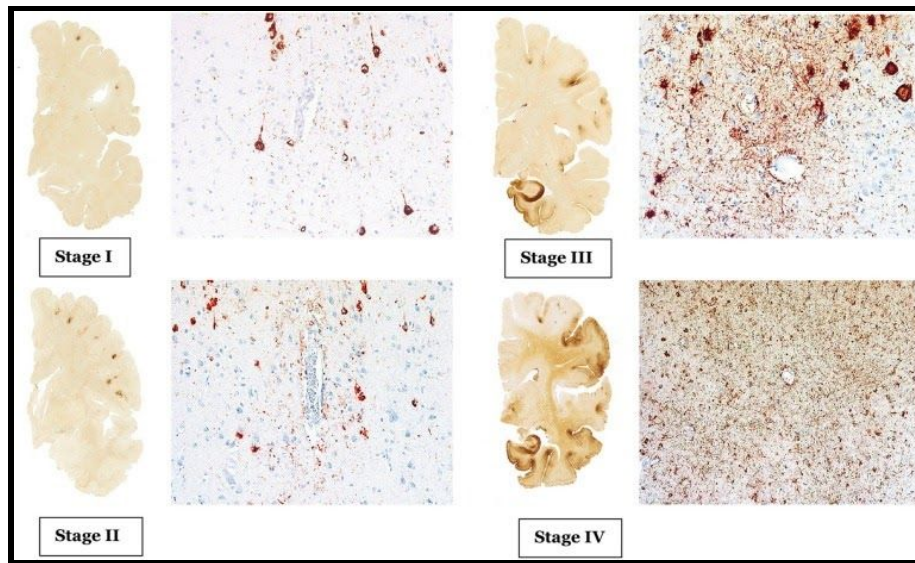
In Stage I, the brain, as a whole, looks normal, but tau begins to show in microscopic areas of the brain (Fesharaki-Zadeh, 2019). In these early stages, doctors find tau in areas such as the cortex of the brain (Fesharaki-Zadeh, 2019). Symptoms of the first stage include mild headaches, mood swings, and loss of attention or concentration (Ortiz, 2018). One distinct feature of most brain degenerative diseases is that the location where the disease begins to grow or spread is responsible for what types of symptoms the patient feels in the early stages of development (“What Is CTE”, 2019). For example, patients who develop tau in the temporal lobe area of the brain in the early stages of CTE are more likely to see early symptoms relating to behavior such as aggression, and mood swings (“What Is CTE”, 2019). On the other hand, patients who, for example, develop tau in the frontal lobe area of the brain in the early stages of CTE see symptoms relating to judgment and decision-making such as lack of attention and memory (“What Is CTE”, 2019). Regardless of the location of tau development, these symptoms generally start to appear in patients in their late 20’s or 30’s (“What Is CTE”, 2019).

In Stage II, abnormalities in the spread of tau protein become macroscopic, or visual to the naked eye (Fesharaki-Zadeh, 2019). It is in this same stage that doctors and neurologists begin to notice the distinct spreading pattern of tau protein in the brain. Ventricles located in the region where the tau is spreading and multiplying become enlarged (Fesharaki-Zadeh, 2019). By this stage, symptoms increase and become more visual to those surrounding the patients. Symptoms in this stage include depression, short-term memory loss, explosivity (Ortiz, 2018). Although less common, some patients suffer from impulsivity, language difficulty, and potential for suicide in the second stage (Ortiz, 2018).

In Stage III, macroscopic abnormalities are more common and appear in most of the sections of the patient's brain (Fesharaki-Zadeh, 2019). In this stage, brain weight loss becomes obvious because of the mild deterioration of the frontal lobe and temporal lobe, and tau becomes prevalent in most lobes of the brain (Fesharaki-Zadeh, 2019). Symptoms of this stage include all symptoms of previous stages, but some symptoms such as memory loss become more common and worse for the patient. Due to the deterioration of the lobes and as a result of all the symptoms, 75% of patients in this stage are considered "cognitively impaired" (Ortiz, 2018).

In Stage IV, global brain weight loss increases dramatically. While a normal brain weighs around 1,300 to 1,400 grams, a patient's brain in this stage weighs around 1,000 grams (Fesharaki-Zadeh, 2019). The 300 or 400-gram loss is due to the major deterioration of the frontal and temporal lobes (Fesharaki-Zadeh, 2019). Symptoms in this stage include all the symptoms stated in the previous stages (Ortiz, 2018). However, in this stage executive dysfunction and memory loss become excessively worse and some patients fall into a state of dementia (Ortiz, 2018). Doctors also noticed that patients in this stage suffer from an extreme

lack of attention and concentration (Ortiz, 2018). Also, around 31 percent of patients studied in this stage were considered “suicidal” at some point (Ortiz, 2018). Less common symptoms include parkinsonism and dysarthria (Ortiz, 2018). Most patients who pass away from CTE, do so because of respiratory failure, cardiac arrest, overdose, or other symptoms related to the last stage of dementia (Ortiz, 2018).



*Figure 1.* Stages of CTE. This figure is a sample brain during the four stages of CTE (Fesharaki-Zadeh, 2019).

Although this disease is a complex disease, simple solutions work as well. Proper guidelines and regulations should be placed to make sure that hits in the game of football are clean. It is not logical to just wait for CTE to build up in one’s brain, then try to stop its spread. If scientists and helmet manufacturers were to try and stop, or at least limit, the disease, fewer cases would occur and many lives would be saved. These guidelines and regulations are the rules of football and clean hits. It is the job of referees and coaches to teach players that certain hits are not allowed and can damage one’s brain, indefinitely. It is upon the coaches of both high school

and NFL to instruct players on how to efficiently initiate a tackle. The most common rule that football players all around the nation should be coached on is called “helmet to helmet”, which prohibits intentional hits in which both players’ helmets collide with a heavy force (Stites, 2018). In the effort to lower concussion rates in the NFL and to set a precedent, the NFL has released updated versions of this “helmet to helmet” rule that is more strict and has a more severe punishment attached to it (Stites, 2018). Although many coaches and players do not favor this rule because it is very controversial, it is a positive step towards making sure our players can live a healthy and brain-disease-free life. Other ill tactics such as “lowering the head” and “sandwich hits” should be monitored and taught as forbidden for players.

When it comes to designing the perfect helmet, it is no easy job. One must consider protection, aesthetic, weight, mobility, and many other factors that affect a football player’s performance. Due to this, designing a helmet that provides all of these different services requires a large amount of money, time, and research. As of now, most scientists do not agree with the notion that modern helmets protect the head. As a matter of fact, they think the opposite: they cause concussions (Maldarelli, 2018).

In the early days of football, players wore very little protection; therefore, many players sustained skull fractures and even internal skull bleeding (Grush, 2016). As the years progressed, more equipment became required and was worn by players because of these injuries. Therefore, nobody can argue that helmets are pointless, rather it is the way that they cushion the brain and skull that is ineffective as of now.

The brain has its own cushioning system. Surrounding the brain is cerebrospinal fluid, which acts as padding between the bone and tissue. However, this fluid is not enough to protect



the brain because it is so thin. When describing how the brain can be damaged in sudden hits, neurologist Barry Kosofsky at Weill Cornell Medicine said: “The brain is like custard floating in the skull, so when the skull stops suddenly and the brain moves forward, the brain can hit the skull” (as cited in Grush, 2016). When the brain hits the skull, a concussion occurs. Every time two players collide, there is a very high chance that their brains may have shifted in their skulls. On average, a football player goes through 1,400-1,500 hits per season, averaging around 14 per game (Sausser, 2012). When considering these large numbers and the stakes that are on the line, designing a helmet becomes a task that is not as easy as many think it is. A helmet protects the head in the same way that an airbag in a car protects the body: by slowing down acceleration (Grush, 2016). The problem with this comparison is that an airbag does the job with a couple of feet of space, while a helmet has only inches of room to absorb a collision and stop the brain from moving (Grush, 2016).

The ideal solution to this problem is in the science of how a helmet absorbs a force. Current helmets absorb little to nothing of the force, which results in the player’s head rattling, due to their hard outside shell. A modern and safe helmet would consist of layers. The outer layer would be a softer layer than normal helmets. To compensate for the forces and fully protect the head, a gyroscopic mechanism is used.

A gyroscopic mechanism consists of more than one sub-assembly, and the motion of one sub-assembly can be isolated from the motion of the other sub-assembly. Through a series of linkages that are hinged with each other, where all hinged components are assisted by elastomeric torsional spring action, the impact on the exterior surface of the helmet can be substantially reduced. By forcing transmitted impact to transfer through a series of

two-force-linkages, the impact force can be dismantled into arrays of smaller component forces. The elastomeric material can be co-molded with harder plastic linkages to generate torsional spring action at all hinges. By positioning arrays of such mechanisms in an axisymmetric fashion and repeating such arrays throughout the space between the interior skin and the exterior skin of the helmet, a multidimensional shock absorption capability can be achieved.

The most important benefit of this type of mechanism is that the force is transferred to the linkages and does not reach the player's skull. As you lay more of these linkages across the layer between the helmet and skull, the force applied can be distributed very easily allowing the linkages to bend minimally. This ensures that the force does not go through the linkages and, in the end, rattle the player's skull.

One of the most essential virtues of Islam is the importance it places on helping and saving lives, which is what a redesigned football helmet is aimed towards. In this regard, in Surat-ul-Maeda, verse 32, Allah (SWT) states in the Qur'an: on that account: "We ordained for the Children of Israel that if anyone slew a person—unless it be for murder or for spreading mischief in the land— it would be as if he slew the whole people: and if anyone saved a life it would be as if he saved the life of the whole people. Then although there came to them Our Messengers with clear Signs, yet even after that many of them continued to commit excesses in the land." This verse refers to what it means to take a life or save one. If one chooses to take a life, it is as if that person has taken the lives of all of humanity. Whilst if one decides to save a life, it is as if that person has saved the lives of all of humanity. This concept is very important because it shows the value of human life, giving Muslims an idea of how rewarding the action of saving a life can be and how detrimental it can be to take a life. Many misunderstand verses like

these in the Qur'an that speak on certain actions and their rewards. Even though a person is not physically saving a life when redesigning this helmet, he or she will still receive the reward of saving hundreds of lives of football players who benefit from this product and any type of research or development that leads to its use. Every time a player puts on that redesigned helmet and continues to live a healthy life because of that person's hard work in designing the helmet, he or she will be rewarded tremendously.

Islam also emphasizes on morale and the will to do the right thing no matter the circumstance. If a true Muslim witnesses injustice or wrongdoing, he must make an effort, in any way, shape, or form, to change what he witnessed for the better. The Prophet Muhammad (SAW) went over this specifically in a recorded hadeeth. On the authority of Abu Sa'eed al-Khudree (may Allah be pleased with him) who said: I heard the Messenger of Allah (ﷺ) say, "Whosoever of you sees an evil, let him change it with his hand; and if he is not able to do so, then [let him change it] with his tongue; and if he is not able to do so, then with his heart — and that is the weakest of faith" [\[Muslim\]](#) ("On The Authority", n.d.). This hadith shows that if a person has a will, he or she can stop wrongdoing or evil, even if it is in the simplest of ways. In another instance, the Prophet (SAW) mentions that even removing harm from a pathway is considered charity. In this case, redesigning a helmet and working to remove this obstacle from a player's "path" of playing the game of football is the action. On the authority of Abu Hurayrah (may Allah be pleased with him) who said: The Messenger of Allah (peace and blessings of Allah be upon him) said, "Every joint of a person must perform a charity each day that the sun rises: to judge justly between two people is a charity. To help a man with his mount, lifting him onto it or hoisting up his belongings onto it, is a charity. And the good word is a charity. And

every step that you take towards the prayer is a charity, and removing a harmful object from the road is a charity” [\[Al-Bukhari\]](#) [\[Muslim\]](#) (“On The Authority”, n.d.)

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