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Perceived Effectiveness of Stem Cell Injections in Adults with Joint Injuries

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PERCEIVED EFFECTIVENESS OF STEM CELL INJECTIONS IN ADULTS WITH JOINT
INJURIES

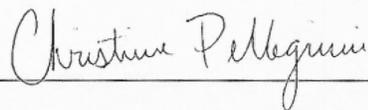
By

Delaney Merrill

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Thesis Summary

Osteoarthritis, which is caused by wear and tear on the joints, is a chronic disease that plagues many people and costs the healthcare system billions each year. There is no cure and traditional treatments lifestyle changes, pain management medications, and surgery all have limitations. However, stem cell therapy is new type of medical treatment that has recently become more popular due to its potential to treat osteoarthritis and other joint injuries by regenerating cartilage.

Stem cell therapy is when stem cells are harvested from a patient's bone marrow or taken from a donor or umbilical cord blood. Then, they are injected into the injured area of the body to help heal any damage. Stem cells, which are not very prominent in adults, are used because they have the ability to become any type of cell in the body. This study focused on the effectiveness of stem cell injections in joints, specifically the hip, knee, and shoulder by having participants complete a survey. Twenty-nine people filled out the survey which asked about treatment protocols, pre and post-treatment pain and mobility levels, and success of the stem cell injection.

Overall, the study found that 77% of people believed the stem cell treatment to be successful and that 72% would recommend it to someone with a similar injury to him or herself. Participants also self-reported less pain, increased levels of mobility, a better overall quality of life following the stem cell injection. Although the sample size in this study was small, the research was able to demonstrate the need for further research on stem cell therapy with more patients and over a longer period of time. Additionally, it shows that stem cells have the potential to be a standard treatment for people with osteoarthritis and joint injuries.

Abstract

Introduction: Osteoarthritis plagues around 27 million Americans. Stem cell injections are a new method of treatment that could potentially cure this by regenerating cartilage in joints.

Purpose: The purpose of this study is to examine the perceived effectiveness of stem cells at regenerating cartilage in joints, specifically the knees, hips, and shoulders. **Methods:**

Participants were recruited via social media, forums, and from healthcare clinics that offer stem cell treatments. They were asked to complete a survey focusing primarily on the treatment protocol and how the injured joint felt post-stem cell injection. Frequencies were calculated to describe problematic joints, treatment history, and perceived effectiveness of the stem cell therapy. **Results:** Twenty-nine people participated in the study. Most were white (93.1%), non-Hispanic or Latino (96.6%), and struggling with an injury due at least in part to degeneration (58.6%). Sixty-six percent were female and 48.3% were between 61 and 75 years old. Fifty-five percent of participants received the injection in the knee, 13% in the shoulder, 8% in the back and 11% in the hip. Most had tried at least one other treatment such as physical therapy unsuccessfully prior. Eighty-three percent of people followed a protocol or schedule from their doctor, which included stem cells with other therapies like platelet rich plasma. Overall, 77% reported success with the stem cell treatment and 72% of the participants would recommend stem cell injections to someone with a similar injury to themselves. **Conclusion:** Stem cells were perceived to be beneficial for the majority of participants in the study. This study was performed on a small scale so conclusions about effectiveness in general cannot be made. Future studies should examine cartilage regeneration for a longer time and on a larger scale with assessments, including an x-ray or MRI. The evaluations should be performed both prior to and after the stem cell injection.

Introduction

Aging is a process that everyone experiences and a major component of this is the body breaking down physically. The muscles start to atrophy, the metabolic rate slows, the immune system does not fight off diseases as well, and joints wear down. The deterioration associated with aging may be magnified if one experienced injuries growing up or was extremely active (Noth et al., 2008). For many of these problems, doctors have found solutions or treatments such as light weightlifting to reduce muscle atrophy or certain diets to increase metabolism, but joint and cartilage wear and tear has been not been as straightforward to treat (Noth et al., 2008). Although different treatments and surgical options exist, none of them have had widespread success because cartilage is very difficult to regrow (Paschos et al., 2017). Cartilage is found in between the vertebral discs, in the joints, and ligaments as well as other places in the body. Injuries from trauma or overuse are challenging to heal when there is a lack of blood supply and since cartilage is avascular, it is challenging to heal or regrow.

Osteoarthritis, the most common type of arthritis, is a disease caused by wear and tear on the joints that affects an estimated 27 million Americans (McIntyre et al., 2018). It occurs primarily in the middle aged and elderly causing inflammation, breakdown of cartilage, changes in bone growth, and deterioration of muscles, tendons, and ligaments (Mecoli, 2019). Some people are predisposed to developing it due to family history, genetics, and past injuries. Women are also more likely to be diagnosed with osteoarthritis than men (CDC OA, 2020). Since the disease causes joint pain and stiffness, it often limits people's day to day activities and makes them less likely to participate in physical activity (Rosemann et al., 2008). Once one stops exercising, they are more likely to suffer from other chronic diseases such as obesity, hypertension, and heart disease (Rosemann et al., 2008). People suffering from chronic diseases

put an enormous strain on the healthcare system. Osteoarthritis was the second most expensive health condition treated in United States hospitals in 2013, accounting for 16.5 billion of the combined costs for all hospitalizations (CDC Costs, 2020). Currently, there is no cure for osteoarthritis; therefore, the only treatment options are pain management medications and strategies for slowing the progression of the disease (Mecoli, 2019). Treatment recommendations include exercise to help reduce stiffness and maintain mobility, weight management, pharmacological treatments, using braces and orthotics, and as a last resort surgery (Zhang et al., 2007). The primary surgical option for treating osteoarthritis, unless one is very young, is a joint replacement, which is expensive and has a long recovery time. When a young person has osteoarthritis, there are some more conservative surgeries that can be performed to temporarily delay joint replacement surgery (CDC OA, 2020). The reason OA is so hard to treat is because it is very difficult to regenerate cartilage. That being said, medicine is constantly evolving and new studies are published almost daily.

Currently, regenerative medicine or the study of the regeneration of cells, tissues, and organs is a field that is on the rise (Singh, 2017). There are many types of regenerative medicine treatments including stem cell therapy, cartilage regeneration surgery, prolotherapy, and platelet rich plasma or PRP injections (Singh, 2017). These treatments can be used on their own or in conjunction with each other. While all of these are fairly new medical innovations, they are being researched extensively since they are more natural ways of healing the body than surgery and can help with diseases or problems associated with aging (Singh, 2017).

In the past few years though, one new experimental treatment that seems extremely promising has risen to the forefront of regenerative medicine- stem cell transplants. In a stem cell transplant, stem cells generally are harvested from the patient's bone marrow or a donor's stem

cells are used (McIntyre et al., 2018). Then, they are injected into the area where cartilage is worn away, such as the knee joint, or an injury to cartilage has occurred, like a torn meniscus. The stem cells help the cartilage in the joint to regenerate so the person no longer experiences the pain of the two bones rubbing together and can avoid a meniscus repair or different type of orthopedic surgery (Paschos et al., 2017).

Stem cells are used for this treatment because they are undifferentiated cells that can serve various functions and can differentiate into a muscle cell (Cafasso, 2016). The majority of cells in the body are already differentiated for a specific job and break down after they divide a few times (Cafasso, 2016). As one ages, the cells decrease in their degree of potency, moving from pluripotent to multi to oligo and finally to unipotent. Pluripotent cells, which adults lack, can turn into anything with the exception of extra embryonic structures like the placenta (Brazier, 2018). Multi-potent cells are generally a specific type of cell such as a blood cell and can become any cell of their lineage. These cells become oligo-potent when they differentiate into a specific type of blood cell such as a white blood cell, which can only form other cells in its category. A unipotent cell can only differentiate into one type of cell and divides continuously (Zakrzewski, 2019).

While adults still have multi-potent cells, these are limited to specific sites in the body, primarily the bone marrow. They are often referred to as mesenchymal stem cells and are good at rebuilding bone and cartilage (Brazier, 2018). For this reason, scientists are primarily investigating these cells and induced pluripotent cells for stem cell therapy to regenerate cartilage. Adult stem cells can also be harvested from your own bone marrow or obtained from a donor and used. However, they can only repair damage to tissues or organs in the specific area of the body they come from as they are already specialized (Cafasso, 2016). Induced pluripotent

cells are created by genetically reprogramming adult somatic cells (Brazier, 2018). This gives them the ability to change into any needed cell, even more stem cells (NIH, 2016). The problem with these cells though is that they could lead to cloning in the future. They have the potential to form a human embryo and therefore, could create a genetic replica of the adult they were originally taken from. (Cafasso, 2016).

Due to the issues mentioned with induced pluripotent and adult stem cells as well as the potential of multi-potent stem cells to aid in cartilage regeneration, mesenchymal stem cells are currently thought to be the best ones to use for stem cell therapy. Regenxx, one of the primary stem cell providers in the United States, uses almost exclusively mesenchymal stem cells. These cells are removed from the bone marrow of the hip of either the patient having the procedure done or a donor. Then, they are centrifuged in the lab to get the highest quantity of stem cells per volume possible. After, the stem cells are injected into the precise spot of the damage, which is predetermined imaging- CT, x-ray, or MRI usually. If the stem cells are not being injected immediately, they have to be stored very carefully at negative eighty degrees Celsius (Regenxx, 2019). In treatments, the stem cells can be combined with platelet rich plasma or ozone (Noth et al., 2008). Many clinics are recommending a plan that includes some combination of PRP, ozone, and stem cells injections as well as therapy. Although, some offer solely stem cells, intravenous stem cells, other types of injections, or a different package of services.

Since stem cells are a new area of research, there are a wide variety of treatment options and it can be difficult to determine which will work best. This research examined the perceived effectiveness of stem cell therapy and similar accompanying therapies in patients with recent joint injuries, specifically to the hip, knee, and shoulder, who were otherwise candidates for surgery or traditional methods of rehabilitation. Patients who had undergone stem cell injections

in their joints were studied by conducting surveys to determine the perceived success rate and the treatment protocols used. Overall, this cutting edge treatment is being used more regularly to treat cartilage damage in the back, knees, hips, and other joints and this data will be used to educate potential patients by giving them patients' perspectives on treatment effectiveness and best protocols as well as information to determine whether he or she is an ideal candidate.

Approach/Methodology

Participants

People of any age that underwent stem cell injections were eligible to participate in the study. Males and females were recruited primarily from two clinics- SC Stem Cell in Columbia, South Carolina and Elite Chiropractic Healthcare in Charleston, South Carolina. Additionally, participants were recruited from several Facebook groups for people undergoing stem cell therapy and on stem cell forums to gain more participants.

An introductory email with a link to the survey was prepared and sent to the clinic patients along with a message from the medical professionals asking their patients to participate in the study. Paper copies of the survey were also kept in the medical offices. On social media, a message explaining the research with a link to the survey was posted. The message included a statement that all data would only be used for the purpose of this study. In order to gather more participants, emails and social media posts were generated multiple times. Since stem cells are a fairly new method of treatment, several avenues were pursued to get an adequate sample size.

Procedures

For the study, participants were asked to complete a multi-part survey. The primary survey consisted of two sections created for this study, including questions on the stem cell treatment plan, how the joint was injured, other treatments tried, and the results of the injection.

Additionally, three surveys that have established scoring systems were used: the Knee Osteoarthritis Outcome Score (KOOS), the Hip Osteoarthritis Outcome Score (HOOS) and the Oxford Shoulder Score (OSS). People who injured their hip, knee, or shoulder joint completed the secondary survey specific to the hurt joint after completion of the primary two sections.

Measures

Demographics and Health History. Participants reported their age range, ethnicity, race and gender. Then, they specified which joint or joints had received the stem cell injection in, how the joint was injured, and any other prior treatments used.

Treatment Protocol. All participants were asked to specify their treatment protocol based on duration, single or multiple stem cell injections, and whether or not they were engaging in post injection physical therapy. They also included if they received other shots such as platelet rich plasma or PRP along with the stem cell injections.

Treatment Results. Participants self-reported the results of their treatments as well as their pre-treatment pain levels. Specific questions asked can be found in Table 1. Participants specified if they followed a treatment protocol and if so, the duration of it. The survey also had those who had received other types of injections rate whether or not they felt those were beneficial. Finally, it inquired as to their pain and mobility level compared to before, whether or not they felt the stem cell treatment was successful and if they would recommend it to others.

Following these sections, participants were asked to complete one of three surveys commonly used to assess joint pain and injuries depending on where they received the stem cell injection. These three surveys targeted those who had injured their hip, knee, and shoulder and were completed considering how the joint felt post-stem cell treatment.

Knee Osteoarthritis Outcome Score (KOOS) (Roos et al., 1998). The KOOS is shown to be reliable and responsive in patients undergoing surgery and physical therapy for a variety of conditions including osteoarthritis and ACL reconstruction (Roos et al., 1998). It has five sub-scales that are scored individually: KOOS Pain, KOOS Symptoms, KOOS Activities of Daily Living (ADL), KOOS Sport/Recreation, and KOOS Quality of Life (QOL). Each question on the KOOS is scored from 0 to 4, with 0 being no problems and 4 being extreme problems. Then, the question scores are combined and divided by 4 to find the section scores. Sub-scales are scored from 0 to 100, with 0 representing extreme issues and 100 being no problems.

Hip Osteoarthritis Outcome Score (HOOS) (Nilsson, A. & Bremander, A., 2011). The HOOS is very similar to the KOOS except it is designed to evaluate symptoms and functional limitations of the hips instead of the knees. It measures the same five outcomes as the KOOS: pain, activities of daily living, other disease specific symptoms, sport and recreation function, and hip related quality of life (Nilsson et al., 2003). It is also scored on the same scale. Each question is scored from 0 to 4, with 0 being no problems and 4 being extreme problems.

Question scores are summed and divided by 4 to find the total section score, which ranges from 0 to 100 with 100 being no issues and 0 equating to extreme problems. The HOOS has been tested and is shown to be valid and reliable in people with hip disability and hip osteoarthritis.

Additionally, it is helpful to use on patients pre and post total hip replacement (Nilsson, A. & Bremander, A., 2011).

Oxford Shoulder Score (OSS) (Angst et al., 2011). The OSS is a twelve question survey that assesses pain and function of the shoulder joint. It is scored on a five Likert scale, 1 = no pain/easy to do, 2 = mild pain/little difficulty, 3 = moderate pain/moderate difficulty, 4 = severe pain/extreme difficulty, and 5 = unbearable/impossible to do, and is primarily used on patients

who have shoulder injuries or have undergone shoulder surgery (Angst et al., 2011). Overall, the Oxford is scored on a scale that goes from 0 to 48. The lower ranges like 0 to 19 indicate that one has a severe problem and is more likely to need surgery than the higher ranges. People who score around 48 usually have minor injuries and a good joint mobility. OSS has a high internal consistency and is considered a valid and reliable measure of patient well-being (Dawson & Fitzpatrick, 2014).

Data Analysis. Descriptive statistics including frequency were used to determine participant demographics and the rate at which each joint is injured. Mean and standard deviation were calculated for each survey section of the Hip Osteoarthritis Outcome Score survey and the Knee Osteoarthritis Outcome Score survey as well as overall for the Oxford Shoulder Score survey. The number of people that used each type of alternative treatment and that injured their knee each way (degeneration, sports, etc.) were calculated. The self-reported number of pain levels decreased was also totaled. Lastly, the percentage of overall success and the total number of successful outcomes for each joint were found.

Results

Participant Characteristics. Twenty-nine people participated in the survey. Demographic information can be found in Table 2. The majority of participants were females (65.5%). Most of the participants were also white, non-Hispanic or Latino and between the ages of 61 and 75.

Injuries, Stem Cell Protocols and Alternative Treatments. Thirteen participants received stem cell injections in more than one joint (44.8%). The most commonly injured joint was the knee (72.4%). Shoulders and other joints followed, accounting for 17.2% of injuries each (Figure 1). Joint injuries were attributed to a variety of causes including accidents (falling), car wrecks and daily activities (Figure 2). Most people attributed their injuries to degeneration (58.6%) and

playing sports (34.5%). Additionally, twenty-five people (86.2%) reported having at least one other treatment such as a cortisone injection or physical therapy, prior to receiving stem cells (Figure 3).

Twenty-four survey participants (82.8%) followed a treatment protocol or schedule given to them by their doctor, which generally included other injections or physical therapy in addition to the stem cell injection. Protocols were primarily three to six months or six months to a year-long. During treatment, only three patients (10.3%) reported receiving more than one stem cell injection in a joint. However, thirteen people (44.8%) were given other injections beside stem cells during their protocol. The most common other injection received was platelet rich plasma or PRP (31%).

Pain Levels and Treatment Success. Prior to receiving stem cells, 89.7% of participants placed their pain level as moderate or extreme. Post treatment 79.3% of participants rated their pain level lower than it was before the injection and 89.7% reported at least a slight improvement in their level of mobility (Figure 4). Participants that received other injections, such as PRP mentioned above, with the stem cells were asked if those were beneficial post treatment as well. The majority of the people that received PRP (n=12) reported at least a slight improvement.

Seventy-seven percent of people believed the stem cell treatment was successful (Figure 5). Additionally, 72% said that they would recommend it to someone with a similar injury to themselves. When the success rate is broken down by joint, the knee had an 85% success rate (Figure 6). Not as many people underwent injections in the shoulder (13%), hip (11%), and back (8%) but for those that did, the results are mixed.

Participants who had knee, hip, or shoulder injuries filled out the KOOS, HOOS, or OSS, respectively. Eighteen people completed the KOOS. The lowest scoring sub-scale overall was

the sports/recreation section with an average of 51.7 (Table 3). The section people had the least difficulty with after the injection was the activities of daily living. The average score for all participants was 77.1 (Table 3). The lowest scoring sub-scales overall for the HOOS were quality of life and sports/recreation as can be seen in Table 3. Activities of daily living were the highest scoring section post stem cell treatment for the hip. The OSS was completed by three people. They scored 13, 28, and 33 on it respectively (Table 4). Higher scores indicate better mobility and quality of life after the stem cell injection.

Discussion

The purpose of this study was to examine the perceived effectiveness of stem cell treatment on regenerating cartilage in joints. Overall, this study found that participants believed the stem cell treatment successfully relieved some of their suffering from cartilage degeneration or lesions due to acute trauma or chronic wear and tear (77%). Participants also said they experienced more joint mobility and less pain post-stem cell treatment. However, the reported KOOS and HOOS results following the stem cell injections showed sports and recreational activities were still a struggle for many people. On the other hand, people stated they had an easier time performing activities of daily living and a better quality of life after treatment.

Several other research studies found similar results when assessing the effectiveness of stem cells. A randomized control study was conducted on patients with evidence of osteoarthritis, who had not responded to other treatments (Vega et al., 2015). The participants received either a stem cell injection or a hyaluronic acid injection. Another similar clinical trial performed using stem cells assessed the effectiveness and optimal dosage of stem cells (Gutpa et al., 2016). In both studies, there were significant improvements in pain and function after a yearlong period and it was concluded that there is a trend toward efficacy with stem cell

treatment, especially at a twenty-five million stem cell dosage (Vega et al., 2015 & Gutpa et al., 2016). The promising results of these studies show that stem cells may have the potential to be used as a primary treatment for osteoarthritis and other injuries. They also indicate that stem cell injections may be a viable alternative to joint replacements for patients suffering from osteoarthritis. Going forward, more research is needed to see the long-term implications of stem cell treatment. This should include the duration of effectiveness (if there is one) and if there are any adverse effects of the treatment.

Twenty-three participants (79.3%) stated that their pain improved at least one level post stem cell treatment, typically decreasing from a moderate pain level to a mild one or from mild to no pain at all. Additionally, twenty-two participants (75.9%) stated that their mobility was moderately or vastly improved afterwards. Another study conducted by injecting stem cells into patients' knee joints supported these results (Kubsik-Gidlewska et al., 2018). They found that patients had better mobility, lower levels of pain, and more cartilage in their knees post-treatment (Kubsik-Gidlewska et al., 2018). These findings are significant because better levels of mobility will allow patients to live healthier lives and reduce their chances of developing other chronic diseases. People with osteoarthritis that stay active as they age are more likely to maintain a healthy weight, less likely to suffer from depression and have a reduced fear of falling (Penninx et al., 2001). That being said, more trials that evaluate participants prior to and post-stem cell injection need to be conducted to identify how much mobility, pain, and cartilage growth are altered as well as the effect stem cell treatment has on people's ability to stay active as they age.

The majority of patients (n=21) in the study received stem cell injections in their knees. In the knees, the reported success rate was 85%. Shoulder, hip, and back injections were also analyzed but the sample size was not great enough in these groups to draw any conclusions. A

trial performed on retired NFL players also saw success in the knees as well as the hips and shoulders (Pettine et al., 2018). In the study, participants underwent a baseline evaluation prior to receiving a stem injection in their osteoarthritic joint. A year later the evaluations were repeated, and participants scored at a minimum 62%, 40%, and 64% higher on knee, shoulder and hip tests, respectively. (Pettine et al., 2018). The improvement and success rates shown here are dramatic and support stem cell therapy as an alternative to surgery. These findings also further demonstrate that stem cells could be a viable treatment for people with osteoarthritis. However, a group of osteoarthritis patients that receives stem cells needs to be followed for many years to identify if joint replacement can be completely avoided and if not, how long it is delayed.

The KOOS scores in this study were self-reported following the stem cell treatment. Then, they were compared to other studies that used the KOOS to conduct both pre and post assessments. Activities of daily living and pain mean scores were 77.1 and 72.1, respectively. Another study reported post-treatment KOOS scores of 80 on activities of daily living and 72 on pain (Chahal et al., 2019). A third research article also published similar findings with a score of 82 on both sections (Nilsdotter et al., 2009). Quality of life and sports/recreation were the two lowest scoring sections across all three studies (Chahal et al., 2019 and Nilsdotter et al., 2009). The sports and recreation score was 51.7 in this study compared to 48 in the other two (Chahal et al., 2019 and Nilsdotter et al., 2009). These results demonstrate that stem cell treatment can make a profound difference in people's lives by allowing them to perform day to day activities with reduced or no pain. In the future, similar research needs to be conducted with a larger group of people and on all of the major joints in which people are receiving stem cell therapy.

This study had several limitations. Primarily, the sample size was small and the duration of the research was short. Therefore, it was difficult to draw definitive conclusions. The

participants also were not very diverse as the majority were white adults over the age of 45. This survey analysis also had many strengths, namely it demonstrated the need for more research to be done on stem cell injections, a relatively new method of treatment for injuries and osteoarthritis. Additionally, the study was completed in a short period of time and had no associated costs.

Conclusion

Overall, this research identified that the majority of people are self-reporting stem cell injections to be effective and to better their quality of life. They also report that stem cell treatment improves their mobility and decreases their pain and other symptoms. These outcomes show that stem cell therapy warrants further study. It is a rapidly expanding area of research in the scientific community and has the potential to become a standard method of treatment for osteoarthritis and joint injuries. Hopefully, more patients will see stem cell treatment as a viable alternative to joint replacement and other surgeries in the near future.

Tables and Figures

Table 1: Survey Questions Regarding Stem Cell Treatment Success and Response Options

How would you describe your pre-stem cell treatment level of pain?				
No pain or discomfort	Mild pain or discomfort	Moderate pain or discomfort	Extreme pain or discomfort	
How would you describe your post-stem cell treatment level of pain?				
No pain or discomfort	Mild pain or discomfort	Moderate pain or discomfort	Extreme pain or discomfort	
How would you compare your pre-treatment activity/mobility level to your level now? Please consider where you were just before treatment.				
Vastly Improved	Moderately Improved	Slightly Improved	No change	Worse
Generally speaking, do you believe the stem cell treatment was successful?				
Yes		No		
After having the stem cell treatment, would you recommend it to other patients with a similar injury?				
Yes		No	Unsure	

Table 2: Population Demographics

Characteristic	N	Frequency (%)
Gender		
Male	10	34.5
Female	19	65.5
Ethnicity		
Hispanic or Latino	1	3.5
Not Hispanic or Latino	28	96.6
Race		
White	27	93.1
American Indian or Alaska Native	1	3.5
Asian	1	3.5
Age Range		
15-30	1	3.5
31-45	6	20.7
46-60	8	27.6
61-75	14	48.3

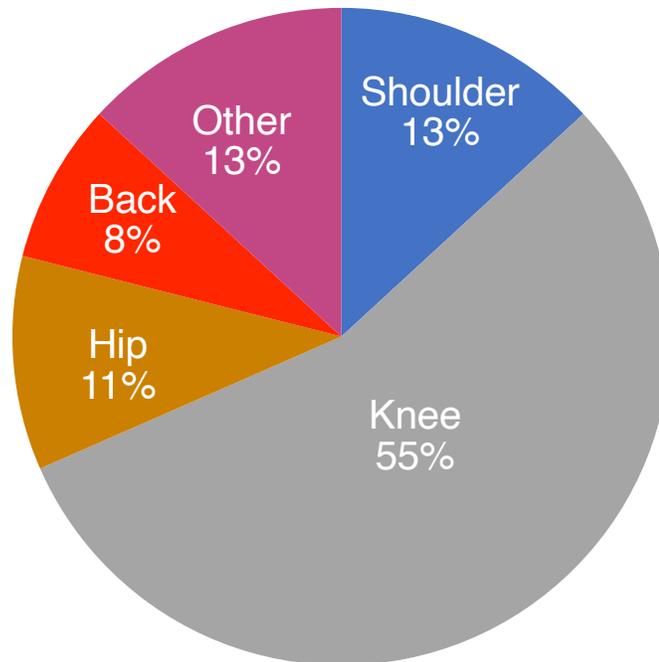
Table 3: KOOS and HOOS Results

KOOS Participants (n=18)	Pain	Symptoms	Activities of Daily Living	Sport/Recreation	Quality of Life
Mean	72.1	70.1	77.1	51.7	55.7
Standard Deviation	21.4	23.5	23.8	33	28.3
HOOS Participants (n=3)	Pain	Symptoms	Activities of Daily Living	Sport/Recreation	Quality of Life
Mean	68.3	67.9	77.9	39.6	37.5
Standard Deviation	14.5	21	19.8	20.6	13.5

Table 4: Oxford Shoulder Score (OSS) Outcomes (n=3)

Participants	Total Score (0 to 48)
Mean	24.7
Standard Deviation	8.5

Figure 1: Injured Joint* (n=29)



*Participants could indicate injuries to multiple joints

Figure 2: How Injury Occurred (n=29)

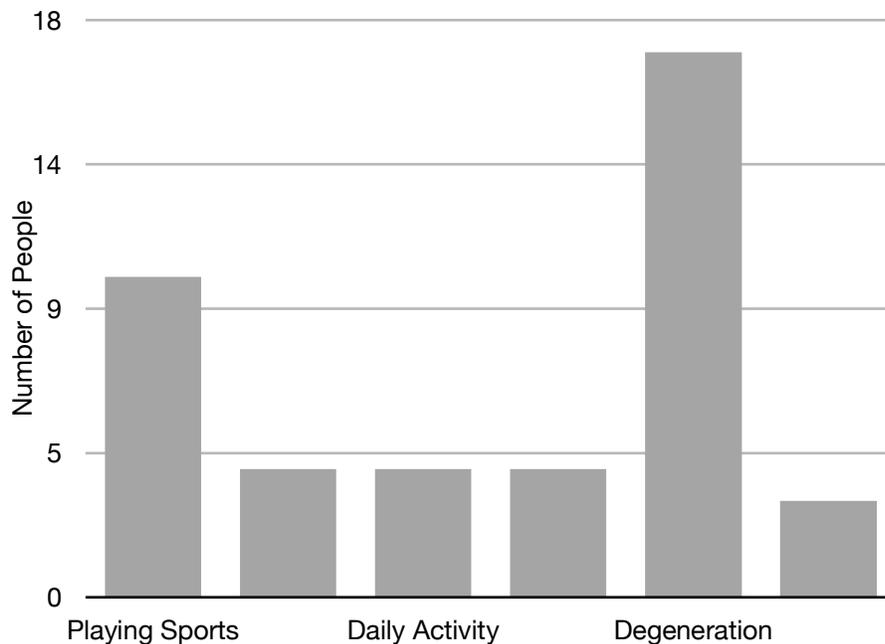


Figure 3: Alternative Treatments Utilized

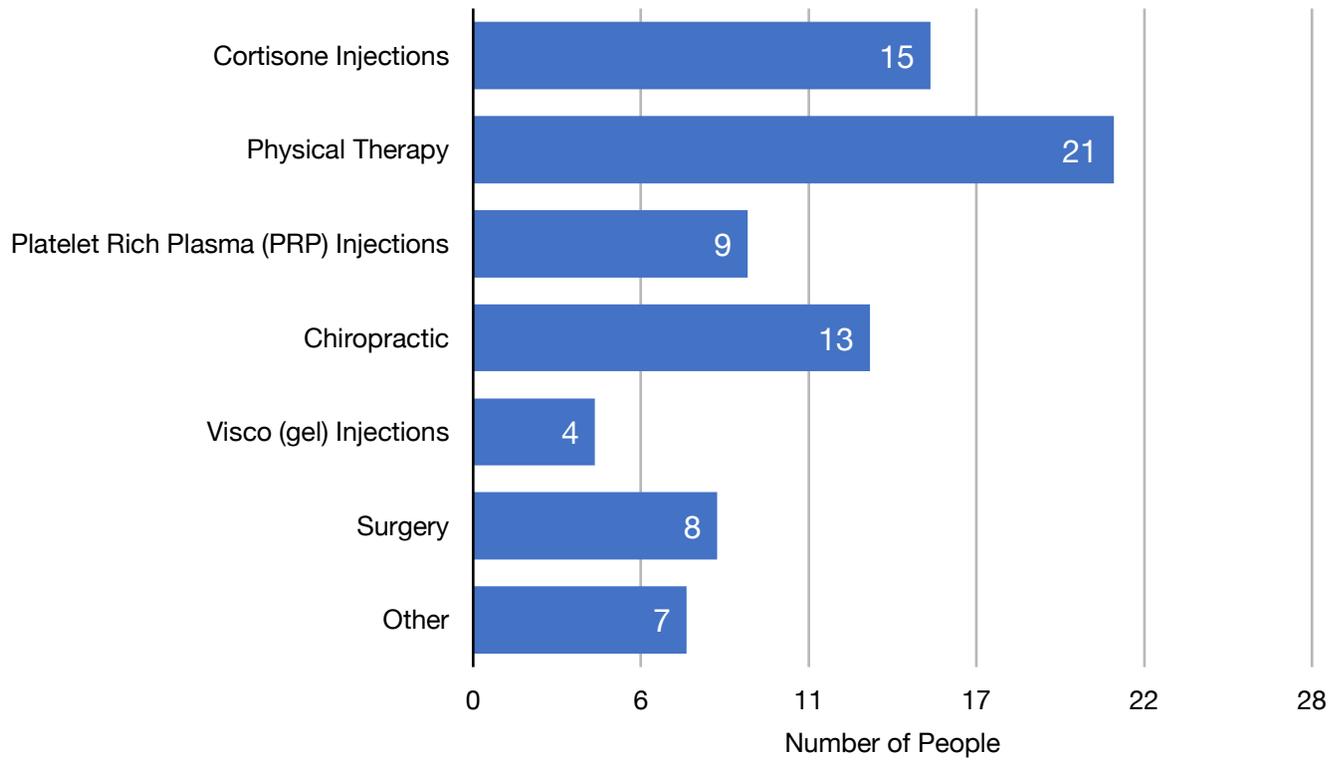


Figure 4: Pain Levels (n=29)

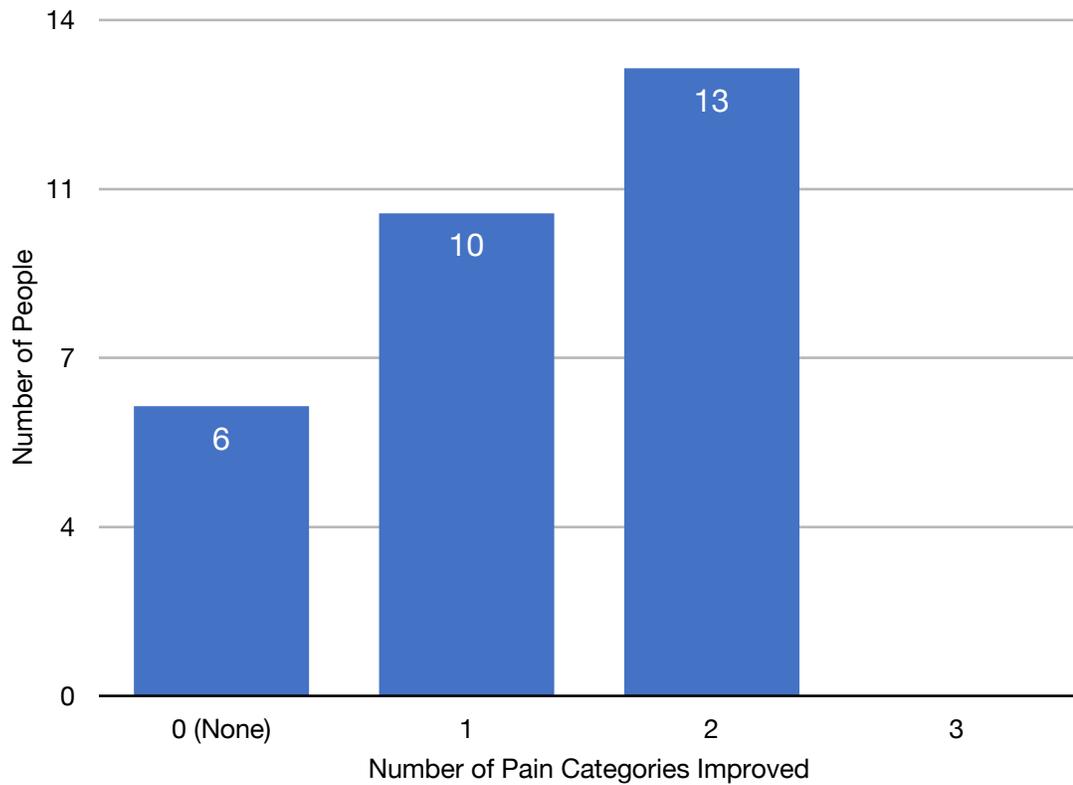


Figure 5: Stem Cell Treatment Outcomes (n=29)

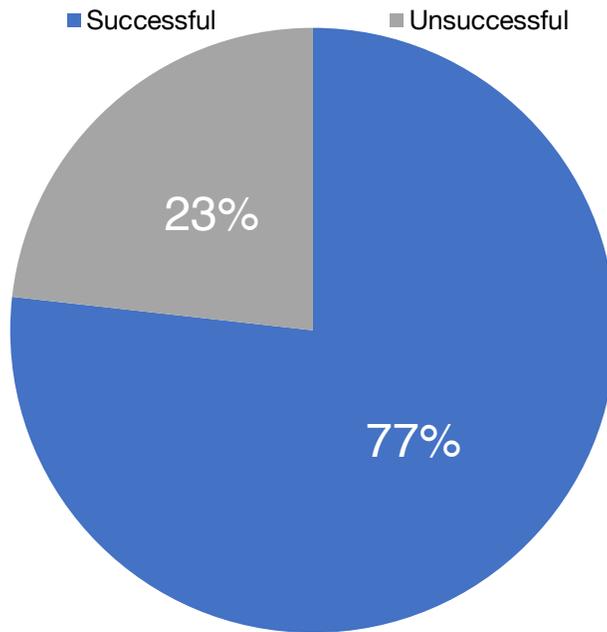
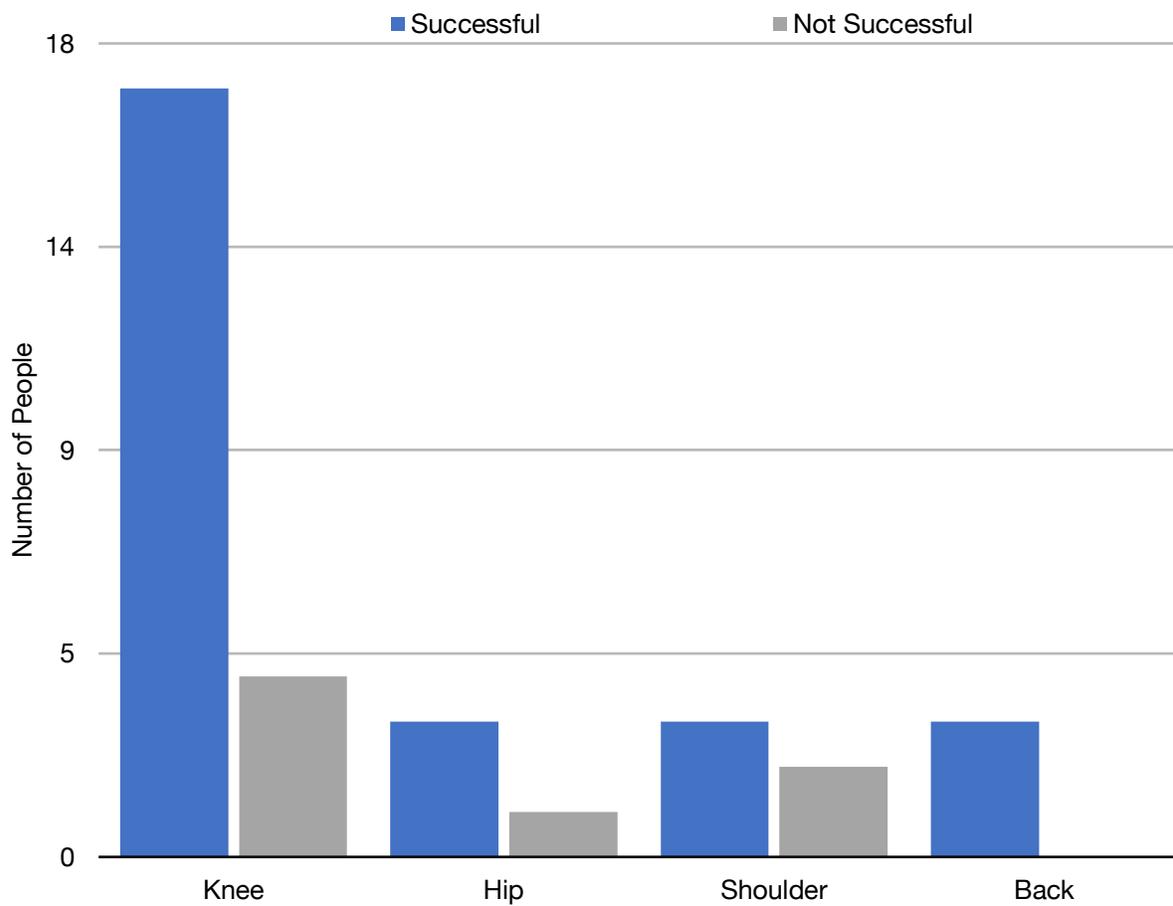


Figure 6: Success Rates by Joint



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