

The Uses, Technology and Ethics surrounding Preimplantation Genetic Diagnosis

When most people think of genetic engineering, the first thing that comes to mind is the concept of designer babies. In the future, we may be able to pre-select traits of our offspring instead of leaving it up to the hands of genetics. Want a baby with green eyes instead of brown? Black hair instead of red hair? The horizon of this field sees a future where your desires can become a reality. However, there are forms of genetic engineering occurring right now. Preimplantation genetic diagnostics essentially strives to accomplish the same task through a different avenue. No gene modification occurs, but genetic analysis is performed in order to select the desired embryo for implantation. Preimplantation genetic diagnosis (PGD) has been used for sex selection purposes, the creation of “savior siblings”, and the avoidance of inherited diseases or disabilities. From a science perspective, this work is an interesting feat to be implemented and further explored. However, with the manipulation of life comes ethical questions and issues. This paper will explore the uses, issues, and ethics surrounding PGD in order to further illuminate where we are in this field and where we have the potential to go in the future.

What is Preimplantation genetic diagnosis?

Preimplantation genetic diagnosis (PGD) involves of a combination of genetic analysis techniques followed by *in vitro* fertilization. Introduced in the early 1990s, PGD consists first of *in vitro* fertilization. In *in vitro* fertilization, eggs from the woman’s body are removed and fertilized by sperm in a laboratory setting outside of the body¹. The womens’ menstrual cycle must be monitored to select an egg at a time when the follicles in the ovaries are mature enough. A hormone, human chorionic gonadotropin, is injected to trigger maturation of the egg and that mature egg can then be removed to combine

with the sperm in a laboratory dish. Usually, about five to six eggs are removed and fertilized and the most viable, healthy looking egg is chosen for implantation. The fertilized egg is then planted back into the women's uterus or into a surrogate and pregnancy starts. So where and how does PGD fit into this process of IVF?

Before the fertilized egg is implanted back into the womb, PGD can be performed in order to study the genetic composition of the embryo. In order to obtain a sample of the embryo to study, the polar body or the blastocyst can be biopsied. In a polar body biopsy, the polar body can be drawn out of the egg with a needle and pipette and this does not affect fertilization rates.ⁱⁱ Biopsying an egg at the blastocyst stage allows for more cell samples to be extracted, but because this is the last stage of development, waiting until this long to biopsy could interfere with the time it takes to analyze and implant. Another stage where samples can be extracted is at the cleavage stage when the eggs have reached their third division.

After the biopsy is performed, analysis occurs. PCR, FISH, and comparative genomic hybridization are methods used to analyze the embryonic sample. PCR studies the DNA through an annealing and amplification process that can be analyzed using electrophoresis. In FISH (fluorescent in-situ hybridization) analysis, detection of a specific sequence on a specific chromosome occurs. A DNA probe is created that is the analog to the segment we are looking for. A fluorescent chemical is attached to this probe, so if the sequence is present in that chromosome then the sample will light up under the microscopeⁱⁱⁱ. In comparative genomic hybridization, DNA from the embryo is labeled with a red fluorescent marker and then is mixed with the control sample (the sequence being sought), which labeled with green markers. Areas with red indicate, a match for what we are testing for while green indicates no match.^{iv} Though FISH is most commonly used, comparative genomic hybridization offers the benefit of looking at the entire genome of

the embryo for matches rather than one chromosome. The sequence to look for can be determined by looking at the genetics of the parents to see what genetic disease could result. After analysis, the embryos we desire can then be implanted as they have been preselected to lack a certain genetic disease or to match certain traits. While IVF can cost around nine thousand dollars, adding PGD to the procedures adds an extra four thousand to seventy-five hundred dollars to the cost^v. So just what is this costly procedure used for and why?

Uses of PGD

To understand the uses of PGD, examples will be provided through the lens of various examples. First, PGD can be used to avoid certain inheritable diseases that favor one gender or another. Through sex selection, chromosome linked diseases can be preselected. Take for instance, a couple with a family history of Duchenne muscular dystrophy. Duchenne presents with symptoms of fatigue, muscle weakness, and confinement to a wheelchair by age 12 and this disease has no cure with average life span of twenty-five years.^{vi} This disease is more common in males than in females. If the mother is a carrier of the diseases and shows no symptoms, the male has a 50% chance of having the disease. If both parents are carriers, then the male child will have this debilitating disease. This is where PGD can play a role. Knowing their family history, the couple could have PGD performed, identify those embryos that are male and discard of them leaving only the option of females (with out the disease) as options for implantation and subsequent pregnancy. This example highlights the use of PGD for medical sex selection purposes. Used in this manner, PGD could serve as sort of a “cure” for sex-linked diseases via the process of elimination of disease ridden embryos. But PGD for sex selective purposes is not always done for medical reasons.

Nonmedical sex selection can be viewed through the example of the Gunn family, interviewed by the Guardian Newspaper. They had always wanted a girl, but ended up having three boys despite following what they called 'a girl diet' after pregnancy number one and two. The mother of the family says, "she got sick of walking past Baby Gap and seeing girl outfits and just getting this pang".^{vii} So, they decided to pay for what they wanted. There was no history of a male-linked disease or other complications, just the pure desire to have girl. The couple went for IVF treatment and then PGD treatment with the purpose of nonmedical sex selection. Seven weeks later, she found out she was pregnant with not one, but twin girls. The practice of using PGD for family balance is growing more common and more controversial. PGD for nonmedical and medical sex selection toes the line of ethics and morality and will be discussed later.

Another controversial use of PGD comes in the form of savior siblings. The Kent family had a 23-month-old daughter suffering from leukemia.^{viii} A stem cell donor was necessary to prevent this leukemia from progressing to acute lymphoblastic leukemia, but no relative were tissue matches and the donor list is often stagnant and takes too long. Using PGD and IVF, the Kent couple was able to select an embryo with similar genetic make-up. They then did HLA screening to confirm a tissue match. This embryo was then implanted in a surrogate, and upon delivery, a healthy baby was born that is also an identical match to the sick child. Blood from the young child's umbilical cord is used a source of stem cells, and, if necessary, bone marrow transplants could be done later in life. PGD lies at the backbone of this practice of creating savior siblings defined as "giving birth to save a life".^{ix} PGD combined with IVF has become a viable treatment option (for those with money) often presented by doctors if all other methods fail and a life is hanging in the balance. Overall, the two uses presented above, sex selection and savior siblings, are the more common uses of PGD for screening and implantation purposes.

Because these usages have been described as manipulation of life, an ethical battle surrounds the use of PGD. Should PGD and its applications be considered legal practices?

Ethics and PGD

Because PGD involves the manipulation of life, it is marred in controversy; but before delving into criticisms against specific applications of it, it is important to note general criticism of PGD. PGD involves the destruction of viable embryos for selective purposes and this does not sit well with critics. As mentioned earlier, PGD costs anywhere between 4,000 and 7,500 dollars and is performed in tandem with IVF, which costs about 9,000 dollars. This procedure could cost, at a minimum, 13,000 dollars so it is evident that it is not for the middle class as health care will not narrow the gap in costs at any amount significant enough to improve access.^x Accessibility of this procedure is low for common people, which does not promote equality and may have social ramifications. It does not seem fair that only the wealthy should be able to afford the use of PGD to avoid diseases or provide a match sibling for an ailing child. Essentially, these inherited diseases could be wiped out in the upper-echelon of society and only be associated with the poorer percent of the population. This again creates an imbalanced paradigm: families with less money cannot screen for diseases, but will end up paying more in health services for their child with the genetic disease while rich families avoid the disease. Even more broadly, using PGD to screen against certain diseases sends a message to those already living with the disease that though they exist, society really doesn't want them. Medically supported sex-selection usage of PGD could be used to screen against diseases that are not life threatening just undesirable. Some worry that PGD will create a society where "aesthetic concerns, convenience...or mere prejudice [will] supplant the inherent dignity due to every human being regardless of how closely he

or she conforms to some ideal of normality or perfection”.^{xi} I would argue that this society already exists and withholding medical technology with beneficial properties will not solve this problem. Our society values beauty, ‘normalcy’, and the unattainable pursuit of perfection and the use of PGD will not greatly harm this.

In addition to the broad concerns surrounding PGD, there are specific battles being waged over PGD for sex selective purposes. A focus group study concerning this issue was conducted and various opinions were presented. Some argue that, whether for non-medical or medical reasons, sex selection should be an option because it is a personal choice just like the choice to have a baby is personal as well. Furthermore, “This is America...you should be able to do what you want” was cited as support for PGD. However, others see it as scientific manipulation that takes away the “miracle of Life” and turns the “gift and process of giving birth into a scientific process”.^{xii} A baby was supposed to be conceived but medical technology has prevented and aborted that creation of life in favor of another and humans are not supposed to have that power. If a child is born with a genetic disease, then it was their fate to have that disease and they should live with it. In regards to PGD for family balancing, results indicated that some study participants believed that more harm could be done to a family who kept trying to have a desired gender and now has five boys in pursuit of that seeming unattainable girl—PGD could be their savior. Other participants believe that you can’t “map out...what your family will look like...and you [should] accept what you get.” Regardless of personal opinion concerning this matter, there are some statistics that lead researchers to believe PGD and sex selection could upset the gender ratio. A Doctor in India has cited that all of his patients using this procedure opted to have boys due to the male-dominated culture. In China, the ratio of boys to girls is already 117 to 100 (under the age of five).^{xiii} In other countries with culture similar to that in India and China where males are thought to be of

more value, we could encounter an exacerbation of the problem of this imbalanced ratio.

In the long run, if females are not being born, then who are the men going to marry in order to procreate and have boys? This sex selective application meant to select for a desirable result could have a undesirable outcome which some critics point out.^{xiv} Taking into consideration both sides of this argument regarding PGD and sex selection, while it seems daunting and unnecessary to undergo IVF and PGD for nonmedical selective purposes, I believe that is a personal choice. If a couple wants a girl and medicine has advanced enough to give them a girl, then that is their decision to make. I do not believe it will upset the ratio of boys to girls in America because our culture is not as male dominated as some cultures in the Eastern World. Furthermore, in countries in the Eastern World, this seems a more medically sound option than dangerous, back-alley abortions or neglect, and harm of undesired girls.^{xv}

In addition to criticism against PGD for sex selection, PGD for use of creating savior siblings is also shadowed in controversy. The main criticism for this application of PGD stems from the belief that this baby is created to be a spare parts baby meant to service the family and the sick child. Critics argue that the child would become a commodity rather than a being to be cared for and loved. Also, the long-term effects of PGD have not yet been discovered so it is unclear whether or not long-term harm is done. Furthermore, what if the savior sibling doesn't end up being able to save the sick sibling and the sick sibling dies? What if the savior sibling finds out he/she was only born to save their sibling? As a result, psychological or emotional damage could be done to that child.^{xvi} An example of this was reference in pop culture in the book-turned movie, *My Sister's Keeper*. The younger sister was born to serve as a donor for her older sister battling leukemia. The younger sister goes through procedure after procedure (sometimes painful) in order to serve as a donor to keep her sister alive. When asked to

donate bone marrow, she sues her parents for medical emancipation. Critics see parallels between fiction and reality in this instance: the savior sibling being treated as a toolbox to fix a sick child sets up an environment in the family that could be damaging and unhealthy. Furthermore, the theme of aborting viable embryos is seen as killing life and shows up in all dissenting positions to applications of PGD. Though I understand why this is ethically questionable, I personally disagree. Sheldon et al makes the argument that regardless of being savior siblings or not, some children are viewed as commodities anyway. Couples have babies to provide an heir, save a marriage, or complete their ideal notion of family. Having a child for a specific purpose or intent is not a new concept and shouldn't be treated as such.^{xvii} Also, while the psychological and emotional well being of a child are important, this damage occurs often without any link to PGD related procedures. Children born into unstable families or rough neighborhoods experience mental damage as well so citing emotional damage as reason to ban PGD is too narrow of an argument that does not accurately reflect supposed consequences of PGD. If PGD was used to select for a savior sibling in order to save another life and the savior sibling is loved, then I disagree with the dissenting position. Just because the child is born for a purpose, does mean that is its sole purpose—it can still be loved and cared for as a parent would with any child. No medical harm is done to the savior sibling, so saving a life trumps the opposition.

Overall, the thread that runs through the critic's argument in both applications of PGD is the notion of manipulating life, getting rid of other life, and 'playing God'. To some, PGD destroys viable embryos, but not life while others believe destroying an embryo is tantamount to destroying life. This controversy also hinges on what one's own personal decision of 'life' is. There will never be common ground sought regarding that argument, which is why I chose not to focus on it specifically. However, though each

application has its specific arguments as well, it is difficult for me to support the systemized limitation of science for all because of one's personal morals and ethics. PGD represents a great advancement in the arena of genetics and the benefits seem to outweigh the risk in this ethical controversy. Given the ethical debate played out above, where are we now and where can PGD take us?

Laws and Future Direction

Currently, the United States has no regulations concerning the use of PGD for any application whether that be medical or non-medical sex selection or savior siblings. However, other nations do have regulations surrounding the use of PGD. Clinics in the UK are under the authority of Human Fertilization and Embryology Authority (HFEA) in their usage of PGD. PGD because of non-medical sex selection is illegal, and in order for PGD to be used for medical reasons, the case must be presented to the HFEA for approval.^{xviii} Canada also follows a model similar to the UK's. Perhaps no regulation exists like this in the United States because we don't have a regulatory body like this or we give power to the states. Some states have laws on embryo research, but their interference with reproductive rights has often been deemed unconstitutional.^{xix} As of now, I do not believe there needs to be regulation over PGD and it's current applications, but that may change as PGD continues to evolve in the arena of genetic engineering. PGD is naturally touted as the precursor to the evolution of designer babies and the ushering in of the era of eugenics. While PGD is a diagnostic procedure and engineering connotes altering genetic information, with more technology and advances in science, we may be able to use PGD to essentially design a baby. What if a gene was found to predispose people for intelligence or athleticism? Parents would be able select to have a smart child. It is this frontier of eugenics that seems problematic as it may be used more as cosmetic tool and we may become too homogenized. However, this is a ways off.

Currently, PGD represents a great genetic tool with many possibilities discovered and undiscovered. Though it may be under fire ethically, it is difficult to ignore its current benefits. One person's morals or beliefs should not dictate laws made surrounding the use of PGD for the public, whether it's nonmedical or medical. I believe PGD for both purposes should be legal and it should be up to the user to come to their own ethical or moral conclusion on whether or not they should use it.

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^{ix} *ibid*

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^{xix} *ibid*