PREIMPLANTATION GENETIC DIAGNOSIS OF GENDER SELECTION IN THE UNITED STATES

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ABSTRACT

Preimplantation genetic diagnosis (PGD) of gender selection for non medical reasons has been considered an unethical procedure by several authors and agencies in the Western society on the basis of disrupting the sex ratio, being discriminatory againsts women and disposal of normal embryos of the non desired gender. In this study, the analysis of a large series of PGD procedures for gender selection from a wide geographical area in the United States, shows that in general there is no deviation in preference towards any specific gender except for a preference of males in some ethnic populations of Chinese, Indian and Middle Eastern origin that represent a small percentage of the US population. In cases where only normal embryos of the non-desired gender are available, 45.5% of the couples elect to cancel the transfer, while 54.5% of them are open to have transferred embryos of the non-desired gender, this fact being strongly linked to cultural and ethnical background of the parents. In addition this study adds some evidence to the proposition that in couples with previous children of a given gender there is no biological predisposition towards producing embryos of that same gender. Based on these facts, it seems that objections to gender selection formulated by ethics committees and scientific societies are not well-founded.

SUMMARY

Preimplantation genetic diagnosis of gender selection for non medical reason is considered unethical by scientific societies and ethics committees claiming that the sex ratio of the population can be disrupted, that it is discriminatory against women and regarding the fate of

normal embryos of the undesired gender. Some studies show there is a biass towards males in the general population suggesting that may be originated by some biological processes. This study of a large series of PGD cases for gender selection shows that there is no deviation towards male or females in the gender preferences of patients from an ethnically diverse western society like the United States, with the exception of some ethic populations of Chinese, Indian and Middle Eastern origin where a biass towards males has been observed. Since these populations represent an extremelly small percentage of the population in the United States, the general sex ratio cannot be disrupted. This study also shows that in couples with previous children of a given gender there is no predisposition to conceive embryos of that gender and that in general there is no biass towards males in the gender of embryos, suggesting that the biass towards males in the general population is not reflected in the early stages of development. Based on these facts, it seems that objections to gender selection formulated by ethics committees and scientific societies are not well-founded.

KEY WORDS

Preimplantation Genetic Diagnosis, gender selection, FISH, ethics committees

INTRODUCTION

Preimplantation genetic diagnosis (PGD) analysis is being used to improve ART outcome (Gianaroli *et al.,* 1999; Munné *et al.,* 1999; Munné *et al.,* 2003), for couples with idiopathic recurrent pregnancy loss (Munné *et al.,* 2005; Garrisi *et al.,* 2008), carriers of structural

chromosome abnormalities (Otani *et al.*, 2006; Escudero *et al.*, 2008), and gene defects (Harper *et al.*, 2002; Fiorentino *et al.*, 2003).

Since aneuploidy of sex chromosomes in human embryos can lead to offspring with Turner's Syndrome, Klinefelter's Syndrome, and other abnormalities compatible with post-natal viability, probes for chromosomes X and Y have been included in most PGD protocols using FISH, with occasional exceptions for indications of structural chromosome abnormalities. Currently, most X-linked genetic defects are diagnosed by PGD using molecular methods that allow specific identification of the mutation (Amor and Cameron, 2008). However, in the recent past, karyotype-based gender determination was used to prevent X-linked disorders like hemophilia. For those syndromes with no clear genetic association and an increased male incidence like autism, FISH is still used for gender determination.

While sex selection of embryos for medical indications is well accepted (Ethics Committee of the American Society for Reproductive Medicine, ASRM, 2001), controversy arises regarding sex selection for family balance or gender preference purposes, which many people believe to be unethical. Two main reasons are cited: one is the risk of biasing sex ratios in the population at-large and/or gender discrimination, and the other that chromosomally normal embryos are being discarded. Considering gender bias, many believe gender selection is discriminatory and sexist; they argue that it would lead to a severe distortion of the sex ratio based on the assumption that a large proportion of couples would select male offspring (American College of Obstetricians and Gynecologists, ACOG, 2007; Robertson 2002; Human Fertilization and Embryology Authority, 2003; International Federation of Gynecology and Obstetrics, FIGO, 2006).

However, several studies have demonstrated that although in some countries like China and India the sex ratio can be distorted in favor of males, in Western societies there is no evidence of such

effect and that gender preferences are usually the result of a desire to have a family with children of both genders (family balancing) (Dahl *et al.,* 2003; Heyd 2003; Jain *et al.,* 2005; Dahl *et al.,* 2006a; Dahl *et al.,* 2006b; Fejes *et al.,* 2006). All but one of these studies have been carried out through opinion surveys, questionnaires, or analysis of newborn data. The one exception is based on results from a series of 92 PGD assays for gender selection in the New York area (Gleicher and Barad, 2007). Overall, the data suggest a strong sex selection towards males remains confined in that area to some minority ethnic groups of Chinese, Middle Eastern/Muslim and Indian origin and that no bias or a slight preference for females is observed among couples of Western origin.

The second controversial issue regarding gender determination is the disposal of chromosomally normal embryos because they are the unwanted gender. As a result of this concern, pre-fertilization techniques like sperm sorting are favored over post-fertilization techniques like PGD (Robertson 2002; ACOG 2007). No studies have been done to determine the proportion of couples seeking PGD for gender determination who are willing (non-absolute preference) or not willing (absolute preference) to transfer embryos from the unwanted gender when these are the only ones available .

The policy of our laboratory has been that we offer PGD for all indications but not specifically for gender determination. However, since FISH procedures usually involve the analysis of X and Y chromosomes, and regulating agencies (i.e. New York State Department of Health) request the disclosure of all genetic information obtained, we know the test is being used by some doctors for gender determination as well as aneuploidy.

Before deciding whether to modify our policy or not, we chose to request further information from those IVF centers sending us PGD samples so we could uncover any bias in gender prediction.

A second purpose of this study was to evaluate the popular belief that families with all same-gender children are predisposed to produce either more girls or more boys than the population at-large. Previous studies of very large birth cohorts have not supported this belief (Maconochie and Roman, 1997). But no published reports have looked directly for gender bias at the stage of fertilization and embryo production within the two subpopulations of couples who have children all of one gender or the other. Here we present the confirmed data of 276 PGD cycles involving gender selection from 53 different IVF centers throughout the United States.

MATERIALS AND METHODS

Sample population ascertainment

The couples included in this study were selected from PGD cycles performed in our referring facilities from January 2007 to August 2008. Centers referring these cycles were asked to provide information on the first (AMA, RPL, etc.) and second indication (gender selection) for PGD, and if gender selection was mentioned, race and gender desired was recorded.

Those confirmed to have requested gender determination were classified according to reason for the request, including X-linked diseases, family balance, gender bias, or unknown; and classified by ethnicity into Chinese, Indian, Middle Eastern and Western (Caucasian, Hispanic and African-American).

Statistical comparisons between groups were made using Chi-square and Fisher's exact test, with a level of significance of $P<0.05$ (GraphPad InStat 3).

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145 **Biopsy, fixation and FISH**

146 Embryos were biopsied on day 3 of development by removing a single blastomere, followed by
147 nuclear fixation using the slightly modified Carnoy method (Velilla *et al.,* 2002). The fixed cells
148 were sent to Reprogenetics laboratories either at Livingston, NJ or South San Francisco, CA, for
149 FISH analysis, and results were provided on days 3 to 5 of embryo development.
150 PGD was performed by FISH as part of the analysis of 5 (X, Y, 13, 18, 21), 9 (X, Y, 13, 15, 16,
151 17, 18, 21, 22) or 12 chromosomes (X, Y, 8, 13, 14, 15, 16, 17, 18, 20, 21, 22) as previously
152 reported (Munné *et al.,* 1998a; Colls *et al.,* 2007). In cycles analyzing 9 and 12 chromosomes,
153 chromosomes X and Y were analyzed by using probes [CEP X, DXZ1 within Xp11.1-q11.1] and
154 [CEP Y, DYZ1 Yq12 For cases where five chromosomes were analyzed, the FISH analysis was
155 performed by using the MultiVysion PGT panel (Abbot, Downers Grove, IL), which includes
156 the same probe for chromosome X used in the 9- or 12-chromosomes test and probe [CEP Y,
157 DYZ3 within Yp11.1-q11.1] for chromosome Y.
158 Our "No Result Rescue" (NRR) approach was applied after the regular FISH panels, in cases
159 where doubtful results for one or more of the analyzed chromosomes were obtained (Colls *et al.,*
160 2007). NRR for chromosomes X and Y was performed by using one of these probes: [Telomeric
161 Xp22.3/Yp11.3, DXYS129], [Telomeric Xq28/Yq12, EST Cdy 16c07] or [LSI Xq12, Androgen
162 Receptor] (Abbott, Downers Grove, IL).
163 FISH signals were scored applying criteria previously described (Munné *et al.,* 1998b)

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165 **RESULTS**

A total of 3,339 PGD cycles using a 5-, 9- or 12-chromosome test were reviewed. Of these, 381 (11.4%) were ascertained to be for gender selection from 53 different US-based IVF centers among more than 150 centers referring case material to us. Of them, 276 (72.4%), stated the preferred gender, while in the remaining 105 (27.6%) there was no disclosure, so they could not be used here.

Of the 276 cases included in the study, 145 (52.5%) were referred from IVF centers located in the Western half of the USA, vs. 131 (47.5%) referred from the Eastern half of the country. The reasons provided were as follows: 21/276 (7.6%) were selecting females due to X-linked diseases, 9 (3.3%) were selecting females to potentially reduce the chances of autism, 36 (13%) were selecting females or males due to family balance, 97 (35.2%) were selecting females or males due to primary gender selection and 113 (40.9%) were selecting females or males without disclosure of the reason.

When we excluded the 30 cases where selection of female embryos was requested for therapeutic reasons we determined that 119/246 (48.4%) of the non-therapeutic requests were for female embryos while 127/246 (51.6%) were selecting for male embryos. However, when gender preference was analyzed taking into account the reason for gender selection and ethnicity, a significant bias toward male selection was seen in couples of Chinese, Indian and Arab/Muslim origin compared with patients of Western origin. Results are summarized in Table 1.

Information regarding the gender of previous offspring was obtained in 30 cases requesting gender selection for family balance, showing that 8 (26.6%) requested family balance after having one child of the opposite requested gender, 15 (50%) after having two, 6 (20%) after having three and 1 (3.3%) after having four.

A total of 1,647 embryos were analyzed from the 246 cases of gender selection for non-therapeutic reasons. The gender outcome of these embryos showed that there was no difference in the embryo sex ratio of couples wanting either males or females. Limiting the analysis to only Western couples, who are less likely to have a bias towards females, and more likely to want family balance, the results showed no difference in the sex ratios regardless of the desired gender. Likewise, no difference in the sex ratio was observed for normal embryos or for embryos abnormal for other chromosomes. Results are summarized in Table 2.

In 33 cases of gender selection for non-therapeutic reasons, none of the normal embryos obtained were of the desired gender. Of these, 18/33 (54.5%) elected to have a transfer of embryos of the initially undesired gender while 15 (45.5%) decided to cancel the transfer. Regarding ethnicity, in the first group, 2/18 (11.1%) were of Indian, Chinese or Middle Eastern origin versus 6/15 (40 %) in the second group.

Table 3 compares a series of 6977 PGD cycles for aneuploidy testing (PGD-A), with known number of embryos replaced, with the cycles of PGD for gender selection (PGD-G) identified in this study. Although IVF centers referring PGD cycles do not always specify the indication for the test, it is obvious form this table that the vast majority of cycles in which 5 chromosomes are tested or less is for the indication of gender selection.

It is also interesting to observe that in both groups of PGD cycles the same number of embryos was replaced (1.5) (Table 3), although the number of chromosomally normal and not replaced was higher in the PGD-G (2.6 embryos) than in the PGD-A group (0.8 embryos). Because the average of embryos tested was actually less in the PGD-G (6.7) than in the PGD-A (8.7), the difference in non-transferred normal embryos is due to the fact that more chromosome abnormalities are detected with 9-12 probes tested, than with 5, and that only 5% of PGD-A

tested for 5 chromosomes compared to 58% of PGD-G (Table 3). Indeed, on average 25% (2.2/8.7) embryos were classified as normal by PGD-A and 63% (4.2/6.7) by PGD-G. Assuming a similar rate of chromosome abnormalities in the PGD-G group, 25% of 6.7 embryos or 1.7 would be normal, barely enough to replace 1.5 of them. This also means that by only testing 5 chromosomes in 58% of cycles, those cycles are replacing less than 1.5 normal embryos and leaving behind potential normal embryos for transfer.

Indeed, when only PGD-G cycles with 9-12 chromosomes tested are taken into account (Table 3) the average number of normal embryos not replaced in the PGD-G group decreases from 2.6 to 1.6, much closer to the 0.8 embryos in PGD-A.

DISCUSSION

In contrast to poll studies that survey opinions regarding gender selection in the general population, our study was designed to evaluate the choices actually made by couples who have decided to gender-select through the use of PGD. Overall, the results obtained in this study are in agreement with previous findings that suggest that in an ethnically diverse Western society, like the United States, sex ratio cannot be disrupted by sex selection. Indeed, our data showed no significant differences regarding gender preference. In the group patients of Western origin, there is actually a slight but not significant preference for females. This finding invalidates the unsubstantiated ethical claim, suggested by some, that sex selection is always a sexist procedure favoring males (United Nations 1995; ACOG 2007; Hanson *et al.*, 2002; Shenfield 2005).

However, a significant deviation towards preference for males was observed in patients of Chinese, Indian and Middle Eastern/Muslim ethnicity. Similar results were obtained by Gleicher

and Barad (2007) also in the analysis of a series of PGD cases for sex selection in the New York area, showing a strong preference for males in the same ethnic subpopulations, but not a significant difference when the overall population is taken into account, although a slight deviation towards males is described. This bias towards males in Gleicher and Barad (2007) and perhaps toward females in our study may be a reflection of the ethnic composition of the group of patients included in the study and thus a reflection of the geographical origin of the samples. In the Gleicher and Barad study, the percentage of Chinese, Indian and Muslim patients is higher, and therefore, the overall results show a slight deviation towards male. However, since the patients included in our study come from 53 different IVF centers throughout the United States, the ethnic composition of the patients included in this study can be considered a more accurate representation of the population composition of the whole country, and therefore the present results are a more accurate representation of the lack of effect of sex selection on the sex ratio.

Dahl *et al.* (2006b) say that for a severe disruption in the sex ratio of a population, there must be a strong preference for a specific gender and at the same time there must be a high demand of assisted reproductive technology with PGD for sex selection. We can agree with the former but simple observation shows the latter need not be present. In China, where the population control laws of the late 1970s require not more than one child per family, a strong preference for males has led to abortion and infanticide of female newborns, creating an excess of males. Chinese society has long fiercely discriminated against females, just as is often the case in Hindu and Muslim societies. The results of male bias mean many males will not find wives, and -- in theory -- that females at last have a choice of suitors. Few women in this situation will accept forcibly arranged marriages or discriminatory mistreatment when multiple choices of husband are

available. There are many examples in the natural world, particularly among herbivores, (Fisher 1930; Maynard Smith 1980) and in the human history (Trivers 1985; Sureau 1999) that echo this situation. It is our opinion, therefore, that in the longer term, an excess of males in a society will have two obvious effects: one, that discriminatory behavior against females will diminish and eventually disappear; and two, any continued activities for direct sex selection will change to return the sex ratio to equilibrium. Thus an unbalanced sex ratio can only be self-correcting in the longer term.

However, in the ethnically diverse United States there is no overall preference for any particular gender when PGD for sex selection is requested, with the exception of some ethnic populations, which represent an extremely small percentage of the US population (Chinese 0.9%, Indian 0.6%) (U.S. Census Bureau 2000). Neither does the United States have a high demand for assisted reproductive technology with PGD for sex selection, since only a small fraction of the total population does request PGD, and of those, only 11.4% also request gender selection.

In our study only 10.9% of the cases referred for sex selection were for a medical reason, usually for female embryos because of X-linked diseases or to decrease the chance of autism which primarily affects males (Yeargin-Allsopp *et al.*, 2003; Chakrabarti and Fombonne, 2005).

Then there is the popular belief that some couples with multiple children of the same gender must have been predisposed in this direction. To assess the validity of this belief, a 1997 study of all 549,048 births in Scotland over a 14 year period, looked at the gender of fourth and fifth newborns from families in which all previous children were of one gender or the other (Maconochie and Roman, 1997). If gender predisposition is a real phenomenon, the gender of the later-born children should be skewed toward the gender of their older siblings. But the data failed to support this hypothesis.

Our study extended these findings by considering the gender ratio of embryos produced by couples who were proactive in their desire to gender-balance an unbalanced family. If there was a predisposition to conceive embryos of one sex, we would expect it to show up within these particular patient groups. But we found no difference in the sex ratio of their embryos, either as a total or taking into account only the embryos diagnosed as 'normal', suggesting that such predisposition does not exist; or, that if there is any biological selection against one gender, it did not occur at this stage of development. However, since 76.6 % of couples in the family balance group requested gender selection after having only one or two previous children, they may not be realistically considered to have a predisposition to produce embryos of a given gender, and a much larger population of couples with 3 or more babies of the same sex would need to be screened.

Based on large-scale cross-cultural statistics of newborns, it can be seen that there is a slight but uniform skewing of sex ratio worldwide in favor of males with an average of 1.05 (Central Intelligence Agency 2004). Different biological factors have been proposed to explain this shift towards males, such as different survival rates between male and female embryos during early embryo development (Crawford *et al.,* 1987; Boklage 2005), nutritional factors (Rosenfeld and Roberts, 2004; Jimenez *et al.,* 2003; Ménézo 2006), evolutionary degeneration of the Y chromosome and differential fertilization potential of X-bearing and Y-bearing sperm (Cheng *et al.,* 2007). However, the present results demonstrate that if there is any factor leading to a bias towards male at the newborn stage, it does not affect the early stages of embryo development or that assisted reproductive technologies neutralize that effect. It certainly does not support a better fertilization potential of Y-bearing sperm (Cheng *et al.,* 2007) at least for babies conceived through ART.

The fate of normal embryos that are not transferred is a difficult moral aspect of this procedure for some persons. Our study showed that 54.5% of couples undergoing gender selection PGD for non-therapeutic reasons elected to have any-sex embryos available transferred when there were no embryos of the desired gender; meaning that 45.5% chose to discard. Taken into account that only 13.4 % of the PGD-G failed to produce normal embryos of the desired gender, 6.1% of all cycles had no transfer due to lack of normal embryos of the preferred gender.

In those cases were no embryos were replaced there was a significant deviation towards Indian, Chinese and Middle Eastern origin (40%) versus the 11.1% found in the group that elected to have embryos transferred even when not the desired gender, which is a natural reflection of those cultural backgrounds.

One can argue that in addition to this 6.1% of cycles with no transfer, many other normal embryos are not replaced because of gender in cycles with transfer. However Table 3 shows that the same average number of embryos is replaced (1.5 embryos) in PGD-A and PGD-G cycles. Extrapolating the number of abnormalities seen in PGD-A (75%) to PGD-G, the number of normal embryos not replaced would be actually less than in PGD-A. In PGD-A the residual number of normal embryos not replaced are usually those of poor morphology since on average <2% of cycles with PGD-A produce frozen embryos. Thus, apparently PGD-G does not increase significantly the number of non-replaced embryos, but this is misleading. For those PGD-G cycles in which only 5 chromosomes were tested, less detection of chromosome abnormalities means that less normal embryos were replaced in total. Thus, to have a less controversial PGD-G program one should test for as many chromosome abnormalities as possible, furthermore when now it is known that embryo biopsy produces a slight to significant detrimental impact on implantation, depending on the biopsier and cells biopsied (Cohen et al. 2007, Goessens et al.

2008, Munne et al. 2007), thus, if the biopsy is to be done, it should confer the maximum selection and thus maximum advantage to that cycle. Testing more chromosomes in PGD-G would prevent that less normal embryos are left non-replaced, since couples may decide to replace those of another gender if non of the desired gender are found, and this possibility will increase with more chromosomes tested. In addition, by testing more chromosomes after the same biopsy, more normal embryos in general will be replaced, and thus the pregnancy outcome should increase. This should be further analyzed with a large dataset.

To conclude, this study demonstrates that sex selection by PGD in an ethnically diverse Western society, like the United States, does not have any significant effect on population sex ratio, does not discriminate against female embryos, and seldom results (6%) in the non replacement of any normal embryos because such embryos were not of the desired gender, provided that the PGD-G test analyzes as many chromosomes as possible. Since these are the main concerns that ethics committees and scientific societies from Western countries raise in support of their opposition to gender selection by PGD, it seems clear that Western objections to gender selection are not well-founded. Furthermore, the alternative to PGD or sperm selection for gender in some Asian countries is infanticide, which is universally repugnant. Thus, for those couples who desire gender selection, earlier methods are clearly preferable. We believe that it is incumbent upon committees and scientific societies who have formulated policy statements on gender selection to start anew with the actual facts in the pursuit of rational policymaking that protects private interests when those interests bear no negative consequences for society at-large.

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Table 1. Gender preference by reason and ethnicity.

Reason	Ethnicity	Cases	Male	Female	significance
Family balance	Middle East	1	1 (100%)	0 (0%)	

528		Chinese	2	1 (50%)	1(50%)	
529		Indian	10	10 (100%)	0 (0%)	
530		Total	13	12 (92.3%)	1 (7.7%)	P<0.05
531		Western	23	12 (52.2%)	11 (47.8%)	P=1.0000
532						
533	Primary selection	Middle East	8	6 (75%)	2 (25%)	
534		Chinese	6	4 (66.6%)	2 (33.3%)	
535		Indian	12	9 (75%)	3 (25%)	
536		Total	26	19 (73.1%)	7 (26.9%)	P=0.1534
537		Western	71	21 (29.6%)	50 (70.4%)	P=0.0252
538						
539	Unknown reason	Middle East	8	8 (100%)	0 (0%)	
540		Chinese	7	7 (100%)	0 (0%)	
541		Indian	8	7 (87.5%)	1 (12.5%)	
542		Total	23	22 (95.7%)	1 (4.3%)	P=0.0017
543		Western	90	44 (48.9%)	46 (51.1%)	P=1.0000
544						
545	Total	Middle East	17	15 (88.2%)	2 (11.8%)	P=0.0255
546		Chinese	15	12 (80.0%)	3 (20.0%)	P=0.1281
547		Indian	30	26 (86.7%)	4 (13.3%)	P=0.0048
548		Total	62	53 (85.5%)	9 (14.5%)	P<0.0001
549		Western	184	74 (40.2%)	110 (59.8%)	P=0.0748
550						

551

Table 2. Gender outcome of analyzed embryos from different groups of patients.

Patient Group	Total Male	Total Female	Normal Male	Normal Female
Total patients	784 (47.6%)	863 (52.4%)	507 (49.6%)	515 (50.4%)
Select Male	418 (49.2%)	432 (50.8%)	278 (50.9%)	268 (49.1%)
Select Female	366 (45.9%)	431 (54.1%)	229 (48.1%)	247 (51.9%)
Western patients	581 (47.1%)	653 (52.9%)	361 (48.6%)	381 (51.4%)
Select Male	251 (49.4%)	257 (50.6%)	158 (50.6%)	154 (49.4%)
Select Female	330 (45.4%)	396 (54.6%)	203 (47.2%)	227 (52.8%)
Family balancing	89 (50.6%)	87 (49.4%)	60 (52.6%)	54 (47.4%)
Select Male	58 (49.6%)	59 (50.4%)	36 (52.2%)	33 (47.8%)
Select Female	31 (52.5%)	28 (47.5%)	24 (53.3%)	21 (46.7%)

Table 3: Comparison of PGD cycles of aneuploidy and gender selection

	PGD for aneuploidy		**PGD for gender selection**	
	#	**Av.**	**#**	**Av.**
Age <35				
cycles	1867		85	
av. Age	31.1		31.1	
# embryos tested	19548	10.5	610	7.2
# embryos normal	6497	3.5	423	5.0
# embryos replaced	3456	1.9	119	1.4
Av. Normal non replaced		1.6	3.6	
cycles with 5 chromosomes tested*	150.0	8.0%	61	71.8%
age 35-39				
cycles	2321		75	
av. Age	37.2		36.9	
# embryos tested	20314	8.8	467	6.2
# embryos normal	5452	2.3	245	3.3
# embryos replaced	3783	1.6	113	1.5
Av. Normal non replaced		0.7	1.8	
cycles with 5 chromosomes tested*	108	4.7%	41	54.7%
age >39				

cycles	2789		86		
av. Age	43.5		44.1		
# embryos tested	20947	7.5	570	6.6	
# embryos normal	3589	1.3	354	4.1	
# embryos replaced	2941	1.1	139	1.6	
Av. Normal non replaced		0.2	2.5		
cycles with 5 chromosomes tested*	102	3.7%	40	46.5%	

Total cycles with 9-12 chromosomes tested

cycles	6617		104	
av. Age		38		38.5
# embryos tested	58167	8.8	703	6.8
# embryos normal	14477	2.2	306	2.9
# embryos replaced	9600	1.4	138	1.3
Av. Normal non replaced		0.8		1.6

Total

cycles	6977		246	
av. Age	38.1		37.4	
# embryos tested	60809	8.7	1647	6.7
# embryos normal	15538	2.2	1022	4.2
# embryos replaced	10180	1.5	371	1.5

Av. Normal non replaced		0.8		2.6	
cycles with 5 chromosomes tested*	360	5.2%	142	57.7%	

* The rest of cycles had 9 to 12 chromosomes tested