Day 3 embryo morphology are critical predictors for euploid blastocyst

Yunhao Liang
Center of Reproductive Medicine, Guangzhou Women and Children's Medical Center, Guangzhou Medical University

Zhanhui Ou
Center of Reproductive Medicine, Guangzhou Women and Children's Medical Center, Guangzhou Medical University

Minna Yin
Center of Reproductive Medicine, Guangzhou Women and Children's Medical Center, Guangzhou Medical University

Yu Deng
Center of Reproductive Medicine, Guangzhou Women and Children's Medical Center, Guangzhou Medical University

Peiling Liang
Center of Reproductive Medicine, Guangzhou Women and Children's Medical Center, Guangzhou Medical University

Zhizheng Chen (chzhh2003@126.com)
Center of Reproductive Medicine, Guangzhou Women and Children's Medical Center, Guangzhou Medical University

Research Article

Keywords: Embryo morphology, PGT, euploid blastocyst

Posted Date: June 13th, 2022

DOI: https://doi.org/10.21203/rs.3.rs-1668976/v1

License: © This work is licensed under a Creative Commons Attribution 4.0 International License. Read Full License
Abstract

Purpose: To determine whether day 3 or day 1 embryo morphologic grading affected euploid blastocyst rate in PGT cycle.

Methods: 2001 embryos were obtained from 219 patients in our IVF center. Embryo morphologic grading dates were collected on day 1 and day 3 respectively. Blastocyst trophectoderm biopsy were considered on day 5 or day 6 and then applied biopsies for aneuploid screening on NGS platform. Chi-square test, Student's t-tests and Mann-Whitney U-tests were used to compare categorical and continuous variables between the cohorts, respectively. Logistic regressions analysis for euploidy were constructed to determine the influence of embryo morphological grading on blastocyst euploidy.

Results: 811 blastocysts were able to biopsy and all the biopsies were successfully amplified for aneuploidy screening. Day 1 pronuclear pattern shown weak association with euploid blastocyst (P<0.05). Day 3 cleavage-stage embryo scoring, including blastomere number (P<0.01, OR=1.156), symmetry (P<0.01, OR=0.710) and fragmentation (P<0.01, OR=0.624) shown association with euploid blastocyst. 8 cells or ≥12 cells embryo obtained highest euploidy rate and Increasing blastomere size difference and fragmentation decreased euploidy rate.

Conclusion(s): Day 3, but not day 1 embryo morphology were suitable predictors for euploid blastocyst. Day 3 morphology provides individualized, visualized and prognostic information about euploid blastocyst. Blastomere number are given properties when selecting day 3 embryo for implantation or blastocyst culturing. So, day 3 embryo Morphology provides guiding for selecting euploid embryo and improving IVF outcomes.

1 Introduction

In past 40 years, IVF success rate had improved remarkably [1–3]. However, the identification of embryonic developmental potential remains a huge challenge [4–6]. Chromosome abnormality is the most common cause for miscarriage and selection of euploid embryo implantation can markedly improve IVF outcomes [7–8]. Morphologic assessment is the primary and viable method for embryo selection. The factors of assessment include oocyte, zygote, cleavage-stage embryo and blastocyst. But the embryonic chromosome status can't accurately evaluate [9–12]. Time-lapse microscopy (TLM) could 24-hours monitoring of embryo development without exposing the embryo outside the incubator. Due to new knowledge of dynamic process of embryo development, this technology has the potential to lead to an improved method of embryo selection. But, the equipment is expensive and harm of 24-hours monitoring to embryo remains controversional. Even more, the cost of equipment and consumables will increase economic burden of patients [13–16].

Preimplantation genetic screening for aneuploid (PGT-A) can improve IVF success rate [17–20]. At early stage, IVF center used blastomere biopsy on day 3 [21]. Within the development of blastocyst culture, vitrification and molecular biology technology, trophoderm biopsy and next generation sequencing (NGS) was wildly used for aneuploid testing [22–23]. Although PGT-A brings many benefits for patients, but damage of trophoderm biopsy on embryo is still unclear [24], some studies considered that trophoderm (TE) also acting a crucial role in embryo development [10]. Several studies have already demonstrated that blastocyst grading can predict euploid blastocyst, but the association is weak or moderate [25–26]. Liu have studied the correlation between day 3 morphologic grading and pregnancy outcomes in PGT cycle that underwent blastomere biopsy. The study represented that poor/fair-quality embryos have much less likelihood to retain viability after biopsy [27]. However, study explore correlation between day 3 morphologic grading and euploid blastocyst which undergoing trophoderm (TE) biopsy is still limited.

Here, we study 219 women who have least one blastocyst can be biopsied. Total 811 biopsied blastocyst were underwent aneuploid screening on NGS platform. All the biopsied blastocyst were tested for aneuploid. Day 1 and day 3 morphologic grading were recorded. We discovered that day 3 not day 1 morphologic grading are predictors for euploid embryo selection.

2 Materials And Methods

2.1 Study design

219 PGT cycles performed between 2017 and 2019 at our IVF center. 811 biopsied blastocyst come from 219 women were involved in our study. The main information of IVF cycle presented in Table 1. Morphologic assessment were performed from day 1 to day 6 after fertilization. All embryo underwent nonselective culture until day 5 or day 6. Good-quality blastocyst were biopsied before vitrification.
2.2 Embryo culture

All oocytes placed in Quinn’s Advantage Fertilization Medium (Origio) supplemented with 5% human serum albumin (HSA) (Irvine Scientific) under oil (Ovoil, Vitrolife) and performed intracytoplasmic sperm injection (ICSI) approximately 4 hours after retrieval and return to incubator for overnight. Embryos were cultured up to the blastocyst stage in 6% CO2 and 5% O2. All embryos moved into G1 (Vitrolife, 10128) from day 1 to day 3 and subsequently move into G2 (Vitrolife, 10029) from day 3 to day 6.

2.3 Morphologic assessment

All embryo’s assessment followed the Istanbul consensus or Gardner’s system for grading human blastocysts. The morphological parameters for zygote scoring on day 1 were number of pronuclei and pronuclear pattern. Only 2 pronuclei zygote was considered for further culturing. Pronuclear pattern was classified into 4 categories (Z1, Z2, Z3, Z4) based on pronuclear appearance. Cleavage-stage embryo scoring on day 3 including blastomere number, degree of fragmentation, size and shape of blastomeres. Degree of fragmentation is the percentage of the volume of the embryo occupied by fragments (1, < 10% fragmentation; 2, 20%-30% fragmentation; 3, 20%-30% fragmentation, 4 > 50% fragmentation). Symmetry defines the size and shape of the blastomeres within the cleavage-stage embryo (1, even division; 2 < 20% difference; 3, 20%-50% difference; 4, > 50% difference). Day 5 and day 6 morphological evaluation of blastocysts include the stage (early, expanding, expanded, hatching or hatched) as well as the quality of the inner cell mass (ICM) and trophectoderm (TE). All embryonic grading was individually recorded and reviewed in real-time by two senior embryologists (28–30).

2.4 TE biopsy and Aneuploidy testing

Blastocyst quality have assessed before TE biopsy. Good-quality blastocyst (grading ≥ 3BB) were considered TE biopsy. All the biopsy procedures performed on heating stage of a Nikon IX-70 microscope, equipped with micromanipulation tools. Procedure details have mentioned in previous report (12). TE biopsies moved into microcentrifuge tubes containing 2 ml PBS and then performed multiple dilacement amplification (MDA) by using REPLI-g Single Cell kit (Qiagen). The biopsies can stored under −20°C for one week if do not performed MDA. Preimplantation genetic testing for aneuploidy for all samples performed at Mi-seq NGS platform (Illumina) following manufacturer’s protocol. Details shown in Figure S1.

2.5 Statistical Analysis

Student’s t-tests or Mann-Whitney U tests were conducted to assess statistically significant differences. Continuous variables are shown as mean ± standard deviation (SD). Binary Logistic analysis was conducted to investigate embryo euploidy and embryonic morphology by defining the binary response parameter as a euploid 1 or aneuploid 2. Categorical variables are shown as rate with 95% confidence interval (CI). Univariate analysis was conducted to compare the euploid embryo rate in different group. P < .05 was considered statistically significant. Statistical analyses were performed by using the Statistical Package for SPSS 19 (IBM, Inc.).

3 Results

3.1 Demographics and IVF cycle characteristics study population

From 2017 January to 2019 December, 219 patients and 2001 2PN fertilized oocytes in IVF-PGT cycle were include in our study. The 219 patients and 2001 2PN fertilized oocytes divided in to 3 group based on indication: 54 patients and 519 embryos were in PGT-M group, 91 patients and 976 embryos...
were in PGT-SR group, 74 patients and 506 embryos were in PGT-SR group. The IVF-PGT cycle’s information and demographics presented in Table 1.

3.2 Assessment of morphology effects on blastocyst euploidy by logistic regression analysis

We assessed the effects of different morphological factors on the blastocyst euploidy by logistic regression analysis, measured by euploid blastocyst development at day 5 or day 6. Day 1 2PN pattern, day 3 blastomere number, symmetry grading and fragmentation grading were included in logistic regression analysis. The results in Table 2 shown that, the blastomere number had the strongest effect on the blastocyst euploidy (OR = 1.156, 95% CI = 1.103–1.121, P < 0.01), followed by blastomere symmetry (OR = 0.710, 95% CI = 0.591–0.852, P < 0.01) and blastomere fragmentation (OR = 0.624, 95% CI = 0.504–0.774, P < 0.01). However, either day 1 PN pattern (P > 0.05) or PGT indication (data not show) didn’t show any association with blastocyst euploidy.

Table 2
Logistic regression analysis of the parameters associated with euploid blastocyst in 219 PGT cycles

<table>
<thead>
<tr>
<th>Parameter</th>
<th>OR</th>
<th>95% CI</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PN pattern</td>
<td>0.976</td>
<td>0.832–1.145</td>
<td>NS</td>
</tr>
<tr>
<td>Blastomere number</td>
<td>1.156</td>
<td>1.103–1.121</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Blastomere symmetry</td>
<td>0.710</td>
<td>0.591–0.852</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Fragmentation</td>
<td>0.624</td>
<td>0.504–0.774</td>
<td>&lt; 0.01</td>
</tr>
</tbody>
</table>

3.3 Univariate analysis of blastomere number, symmetry and fragmentation analysis in different group

We further analyzed association of blastomere number and euploid blastocyst in three PGT group. Embryos are divided into 9 sub-group based on blastomere number in each group (Fig. 1A). In PGT-M group, 9 blastomere embryo in day 3 obtained the highest euploid rate, followed ≥12 and 8 blastomere embryo (0.364 VS 0.346 VS 0.310, Fig. 1A, Table 3). In PGT-SR group, ≥12 blastomere embryo in day 3 had the highest euploid rate, followed 8 and 7 blastomere embryo (0.220 VS 0.188 VS 0.177, Fig. 1A, Table 3). In PGT-A group, 8 blastomere embryo in day 3 also got the highest euploid rate, followed 9 and ≥12 blastomere (0.293 VS 0.262 VS 0.242, Fig. 1A, Table 3). Finally, we analyzed the total data of the three group, ≥12 blastomere embryo in day 3 represented highest euploid rate followed 8 and 9 blastomere embryo (0.260 VS 0.248 VS 0.241, Fig. 1A, Table 3). For the embryo symmetry, even embryo obtained highest euploid rate followed 8 and 9 blastomere embryo (0.260 VS 0.248 VS 0.241, Fig. 1A, Table 3). For the embryo symmetry, even embryo obtained highest euploid rate followed 8 and 9 blastomere embryo (0.260 VS 0.248 VS 0.241, Fig. 1A, Table 3). For the embryo symmetry, even embryo obtained highest euploid rate followed 8 and 9 blastomere embryo (0.260 VS 0.248 VS 0.241, Fig. 1A, Table 3). For the embryo symmetry, even embryo obtained highest euploid rate followed 8 and 9 blastomere embryo (0.260 VS 0.248 VS 0.241, Fig. 1A, Table 3). For the embryo symmetry, even embryo obtained highest euploid rate followed 8 and 9 blastomere embryo (0.260 VS 0.248 VS 0.241, Fig. 1A, Table 3). For the embryo symmetry, even embryo obtained highest euploid rate followed 8 and 9 blastomere embryo (0.260 VS 0.248 VS 0.241, Fig. 1A, Table 3). For the embryo symmetry, even embryo obtained highest euploid rate followed 8 and 9 blastomere embryo (0.260 VS 0.248 VS 0.241, Fig. 1A, Table 3). For the embryo symmetry, even embryo obtained highest euploid rate followed 8 and 9 blastomere embryo (0.260 VS 0.248 VS 0.241, Fig. 1A, Table 3). For the embryo symmetry, even embryo obtained highest euploid rate followed 8 and 9 blastomere embryo (0.260 VS 0.248 VS 0.241, Fig. 1A, Table 3). For the embryo symmetry, even embryo obtained highest euploid rate followed 8 and 9 blastomere embryo (0.260 VS 0.248 VS 0.241, Fig. 1A, Table 3). For the embryo symmetry, even embryo obtained highest euploid rate followed 8 and 9 blastomere embryo (0.260 VS 0.248 VS 0.241, Fig. 1A, Table 3). For the embryo symmetry, even embryo obtained highest euploid rate followed 8 and 9 blastomere embryo (0.260 VS 0.248 VS 0.241, Fig. 1A, Table 3). For the embryo symmetry, even embryo obtained highest euploid rate followed 8 and 9 blastomere embryo (0.260 VS 0.248 VS 0.241, Fig. 1A, Table 3). For the embryo symmetry, even embryo obtained highest euploid rate followed 8 and 9 blastomere embryo (0.260 VS 0.248 VS 0.241, Fig. 1A, Table 3). For the embryo symmetry, even embryo obtained highest euploid rate followed 8 and 9 blastomere embryo (0.260 VS 0.248 VS 0.241, Fig. 1A, Table 3). For the embryo symmetry, even embryo obtained highest euploid rate followed 8 and 9 blastomere embryo (0.260 VS 0.248 VS 0.241, Fig. 1A, Table 3). For the embryo symmetry, even embryo obtained highest euploid rate followed 8 and 9 blastomere embryo (0.260 VS 0.248 VS 0.241, Fig. 1A, Table 3). For the embryo symmetry, even embryo obtained highest euploid rate followed 8 and 9 blastomere embryo (0.260 VS 0.248 VS 0.241, Fig. 1A, Table 3). For the embryo symmetry, even embryo obtained highest euploid rate followed 8 and 9 blastomere embryo (0.260 VS 0.248 VS 0.241, Fig. 1A, Table 3). For the embryo symmetry, even embryo obtained highest euploid rate followed 8 and 9 blastomere embryo (0.260 VS 0.248 VS 0.241, Fig. 1A, Table 3). For the embryo symmetry, even embryo obtained highest euploid rate followed 8 and 9 blastomere embryo (0.260 VS 0.248 VS 0.241, Fig. 1A, Table 3). For the embryo symmetry, even embryo obtained highest euploid rate followed 8 and 9 blastomere embryo (0.260 VS 0.248 VS 0.241, Fig. 1A, Table 3). For the embryo symmetry, even embryo obtained highest euploid rate followed 8 and 9 blastomere embryo (0.260 VS 0.248 VS 0.241, Fig. 1A, Table 3). For the embryo symmetry, even embryo obtained highest euploid rate followed 8 and 9 blastomere embryo (0.260 VS 0.248 VS 0.241, Fig. 1A, Table 3). For the embryo symmetry, even embryo obtained highest euploid rate followed 8 and 9 blastomere embryo (0.260 VS 0.248 VS 0.241, Fig. 1A, Table 3). For the embryo symmetry, even embryo obtained highest euploid rate followed 8 and 9 blastomere embryo (0.260 VS 0.248 VS 0.241, Fig. 1A, Table 3). For the embryo symmetry, even embryo obtained highest euploid rate followed 8 and 9 blastomere embryo (0.260 VS 0.248 VS 0.241, Fig. 1A, Table 3). For the embryo symmetry, even embryo obtained highest euploid rate followed 8 and 9 blastomere embryo (0.260 VS 0.248 VS 0.241, Fig. 1A, Table 3). For the embryo symmetry, even embryo obtained highest euploid rate followed 8 and 9 blastomere embryo (0.260 VS 0.248 VS 0.241, Fig. 1A, Table 3). For the embryo symmetry, even embryo obtained highest euploid rate followed 8 and 9 blastomere embryo (0.260 VS 0.248 VS 0.241, Fig. 1A, Table 3). For the embryo symmetry, even embryo obtained highest euploid rate followed 8 and 9 blastomere embryo (0.260 VS 0.248 VS 0.241, Fig. 1A, Table 3). For the embryo symmetry, even embryo obtained highest euploid rate followed 8 and 9 blastomere embryo (0.260 VS 0.248 VS 0.241, Fig. 1A, Table 3). For the embryo symmetry, even embryo obtained highest euploid rate followed 8 and 9 blastomere embryo (0.260 VS 0.248 VS 0.241, Fig. 1A, Table 3). For the embryo symmetry, even embryo obtained highest euploid rate followed 8 and 9 blastomere embryo (0.260 VS 0.248 VS 0.241, Fig. 1A, Table 3).
Table 3
Embryo euploid rate at different cleavage-stage embryo grading in 3 PGT groups

<table>
<thead>
<tr>
<th>Blastomere number</th>
<th>PGT-M</th>
<th>PGT-SR</th>
<th>PGT-A</th>
<th>PGT-M + SR + A</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Embryo number</td>
<td>Euploid number</td>
<td>Euploid rate</td>
<td>Embryo number</td>
</tr>
<tr>
<td>≤ 4</td>
<td>87</td>
<td>1</td>
<td>0.011</td>
<td>143</td>
</tr>
<tr>
<td>5</td>
<td>53</td>
<td>5</td>
<td>0.094</td>
<td>88</td>
</tr>
<tr>
<td>6</td>
<td>60</td>
<td>6</td>
<td>0.100</td>
<td>126</td>
</tr>
<tr>
<td>7</td>
<td>66</td>
<td>14</td>
<td>0.212</td>
<td>147</td>
</tr>
<tr>
<td>8</td>
<td>155</td>
<td>48</td>
<td>0.310</td>
<td>303</td>
</tr>
<tr>
<td>9</td>
<td>44</td>
<td>16</td>
<td>0.364</td>
<td>84</td>
</tr>
<tr>
<td>10</td>
<td>20</td>
<td>3</td>
<td>0.150</td>
<td>32</td>
</tr>
<tr>
<td>11</td>
<td>8</td>
<td>1</td>
<td>0.125</td>
<td>12</td>
</tr>
<tr>
<td>≥ 12</td>
<td>26</td>
<td>9</td>
<td>0.346</td>
<td>41</td>
</tr>
</tbody>
</table>

| Symmetry          | Euploid rate | Embryo number | Euploid number | Embryo number | Euploid number | Embryo number | Euploid number | Embryo number | Euploid number | Embryo number | Euploid number | Embryo number | Euploid number |
|-------------------|--------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| 1                 | 257          | 60            | 0.233         | 459           | 77            | 0.168         | 282           | 69            | 0.245         | 998           | 206           | 0.206         |
| 2                 | 173          | 33            | 0.191         | 328           | 43            | 0.131         | 153           | 20            | 0.131         | 654           | 96            | 0.147         |
| 3                 | 87           | 10            | 0.115         | 185           | 9             | 0.049         | 69            | 9             | 0.130         | 341           | 28            | 0.082         |
| 4                 | 2            | 0             | 0.000         | 4             | 0             | 0.000         | 2             | 0             | 0.000         | 8             | 0             | 0.000         |

<table>
<thead>
<tr>
<th>Fragmentation</th>
<th>Euploid rate</th>
<th>Embryo number</th>
<th>Euploid number</th>
<th>Embryo number</th>
<th>Euploid number</th>
<th>Embryo number</th>
<th>Euploid number</th>
<th>Embryo number</th>
<th>Euploid number</th>
<th>Embryo number</th>
<th>Euploid number</th>
<th>Embryo number</th>
<th>Euploid number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>350</td>
<td>84</td>
<td>0.240</td>
<td>585</td>
<td>97</td>
<td>0.166</td>
<td>342</td>
<td>76</td>
<td>0.222</td>
<td>1277</td>
<td>257</td>
<td>0.201</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>93</td>
<td>14</td>
<td>0.151</td>
<td>234</td>
<td>29</td>
<td>0.124</td>
<td>101</td>
<td>20</td>
<td>0.198</td>
<td>428</td>
<td>63</td>
<td>0.147</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>67</td>
<td>2</td>
<td>0.030</td>
<td>136</td>
<td>3</td>
<td>0.022</td>
<td>53</td>
<td>2</td>
<td>0.038</td>
<td>256</td>
<td>7</td>
<td>0.027</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>9</td>
<td>0</td>
<td>0.000</td>
<td>21</td>
<td>0</td>
<td>0.000</td>
<td>10</td>
<td>0</td>
<td>0.000</td>
<td>40</td>
<td>0</td>
<td>0.000</td>
<td></td>
</tr>
</tbody>
</table>

4 Discussion

Embryo selection and euploid embryo transplantation were critical steps for improving pregnancy rate. In our study, 219 patients and 2001 embryos were included. As patient’s indication didn’t associate with euploid blastocyst, patients were divided into 3 group, PGT-M, PGT-SR and PGT-A based on their indication. We found several euploid embryo predictors according to IVF-PGT morphologic data. Good quality blastocysts were underwent TE biopsy and then sent for MDA and NGS-based euploid screening. After statistic analysis, the results shown that day 3 embryonic blastomere number (OR=1.315, P<0.01), blastomere fragmentation (OR=0.900, P=0.01) and blastomere symmetry (OR=0.621, P<0.01) can predict euploid blastocyst and the blastomere number was the strongest factor to effect blastocyst euploidy. However, day 1 2PN pattern didn’t show statistic significant difference with euploid embryo. Tesarik’s study demonstrated that, but similar to Faramarzi’s results [31-32]. We speculated that, 2PN pattern was evaluated by different method and the human factors can’t be ignored. We further study the effect of different blastomere number on embryonic euploid in three groups. 9 blastomere embryo got highest euploid rate on PGT-M group, but 8 blastomere embryo got highest euploid rate in PGT-SR and PGT-A group. In common opinion, 7-9 blastomere embryo usually considered the best choice for transplantation, but in our study embryo within ≥12 blastomere maybe a better choice than 7 or 9 blastomere embryo.

Recently, a variety of technologies for euploid blastocyst selection have been developed. Preimplantation genetic testing for aneuploidy is an attractive technology that has the potential to increase IVF success rates[17]. However, the impairment of TE or blastomere biopsy to embryonic developmental potentiality is still controversial and biopsy increasing the time exposure out of incubator [18-19]. Day 5 or day 6 blastocyst scoring have been confirmed as a feasible method for embryo selection. But, blastocyst scoring can’t be applied in embryo only culture to day 3, and about 40% embryos isn’t able to reach blastocyst stage. On the other hand, day 3 embryo scoring system involve more parameters than blastocyst scoring system, so day 3 embryo assessment could offer more morphologic information than day 5 or day 6. Time-lapse microscopy is a novel technology for optimizing embryo selection. Many studies have demonstrated that some embryokinetics parameters are useful for embryo selection, but the golden standard is still lacking. The impairment of exposure embryo under camera lamplight very 5 mins is still unclear [13-15]. This study need more data to further
confirm the benefit of IVF cycle success rate. Recent attention has focused on developing noninvasive method in PGT. This method analysis cell-free DNA in blastocoelic fluid or culture fluid. Although noninvasive method decreased the impairment on embryo, but the accuracy and specificity need improve [33-35].

5 Conclusion

In conclusion, Our study demonstrated that day 3 embryonic blastomere number, symmetry and fragmentation were predictors for euploid blastocyst. But, day 1 2PN pattern didn't influence euploid blastocyst. 8 cell embryo in day 3 are good choice for blastocyst culture or implantation. This study will improve outcomes of IVF patients.

Declarations

Ethical approval and consent to participants

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This study was approved by Reproductive Medical Ethics Committee of Guangzhou Women and Children's Medical Center and written informed consent was obtained from all subjects[2019-10].

Consent to publication

Not Applicable

Data availability

The data that support the findings of this study are available from Guangzhou Women and Children's Medical Center but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of Guangzhou Women and Children's Medical Center.

Author contribution

YL and ZO collected samples and clinical data. ZO, MY and YD performed clinical classifications, diagnosis, and management of PGT patients. YL, ZO, PL and ZC performed the research. YL and ZC designed the study, analysed the data and wrote the paper. ZC supervised the research. All authors reviewed and approved the manuscript.

Conflict of Interest

The authors declare that they have no conflict of interest.

Funding

This study was funded by Guangzhou Women and Children's Medical Center (YIP-046).

Acknowledgement

We would like to thank the entire Center of Reproductive Medicine staff for supporting this study in many ways, including information storage, data analysis and discussions.

References


Figures

Figure 1

Univariate analysis of day 3 morphological grading factors in PGT embryos. Univariate analysis of day 3 embryo blastomere number (A), symmetry grading (B) and fragmentation grading (C) in PGT-A (red), PGT-SR (blue), PGT-M (green) and PGT total (black).

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- FigureS1.jpg
- Supplementmaterials.docx