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Artificial Intelligence based oocyte scores: their relationship with morphological variables and predictive value for blastocyst development

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INTRODUCTION

The implementation of artificial intelligence (AI) algorithms has revolutionized oocyte evaluation in assisted reproduction, with many clinics already adopting deep-learning based tools that provide standardized basis for clinical decision-making. However, understanding whether visible morphological variables, such as zona pellucida thickness, polar body size, or oocyte area, are linked to the scores generated by these algorithms may help demystify their "black box" nature and enhance embryologists' confidence in their use. Although deep learning algorithms for oocyte assessment do not explicitly analyze these variables, exploring their potential relationship to AI-generated scores could deepen our understanding of the technology and its clinical applications.

OBJECTIVE

To investigate the relationship between oocyte morphological variables and AI-based oocyte scores, and to evaluate their predictive value for blastocyst development in comparison with morphological measurements.

METHODS

This retrospective study analyzed 718 oocyte images (513 from donors, 205 from patients) obtained from Embryoscope Time-Lapse systems just after ICSI. Oocyte images were analyzed using a deep-learning based AI algorithm (Magenta^{TM}, Future Fertility, Canada), which assigns scores (0–10) correlated with blastocyst development. For analysis, Magenta scores were divided into four equally sized groups: G1 (0–2.5), G2 (2.6–5), G3 (5.1–7.5), and G4 (7.6–10). Morphological parameters, including oocyte area (μm^2), polar body area (PBA) (μm^2), zona pellucida thickness (ZP) (μm), and perivitelline space (PVS) (μm), were manually measured by one operator. ZP thickness was measured at three different points, and the average was calculated (Fig. 1). For PVS, the widest dimension was recorded. Morphological ratios (e.g., oocyte area/PVS, oocyte area/ZP, PVS/ZP, PBA/PVS) were calculated to assess proportionality. Statistical analyses included Pearson correlations and regression models to explore associations between variables. Predictive performance for blastocyst development was assessed using ROC curve analysis and the corresponding AUC.

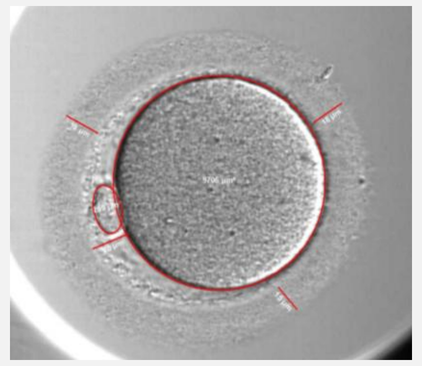

Figure 1. Oocyte morphological assessment post-ICSI. Measurement of oocyte area, zona pellucida thickness, perivitelline space and polar body dimensions

RESULTS

Oocytes that reached blastocyst stage received significantly higher AI-based scores than those that did not (6.8±2.53 vs. 5.9±2.87)*. Blastocyst rates increased across AI score groups (Fig. 2)*. Morphological variables, such as oocyte area, ZP, PVS, varied significantly across groups (Table 1 and Fig. 3)*. Oocytes in the lowest-scoring group (G1) had larger areas and less proportional dimensions, as shown by higher oocyte area/PVS and oocyte area/ZP ratios, and by a smaller PVS/ZP. Regression models identified oocyte area, PBA, PVS, and oocyte age as significant predictors of AI-based scores*. When used to predict blastocyst development, only oocyte area remained significant (AUC=0.55±0.02). However, adding AI-based scores replaced oocyte area as the sole predictor, improving model's performance (AUC=0.59±0.02) (Table 2). These findings suggest that while morphological variables contribute to understanding oocyte quality, AI-based scoring integrates additional image-based features, making it a more powerful tool for predicting blastocyst development.(*p<0.05).

Figure 2. Blastocyst rate in each Magenta group

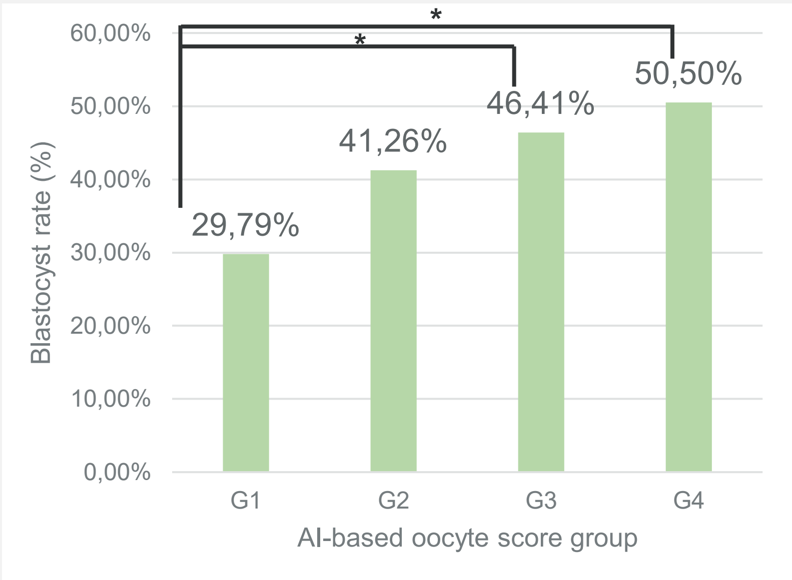

Figure 3. Mean oocyte area in each Magenta group

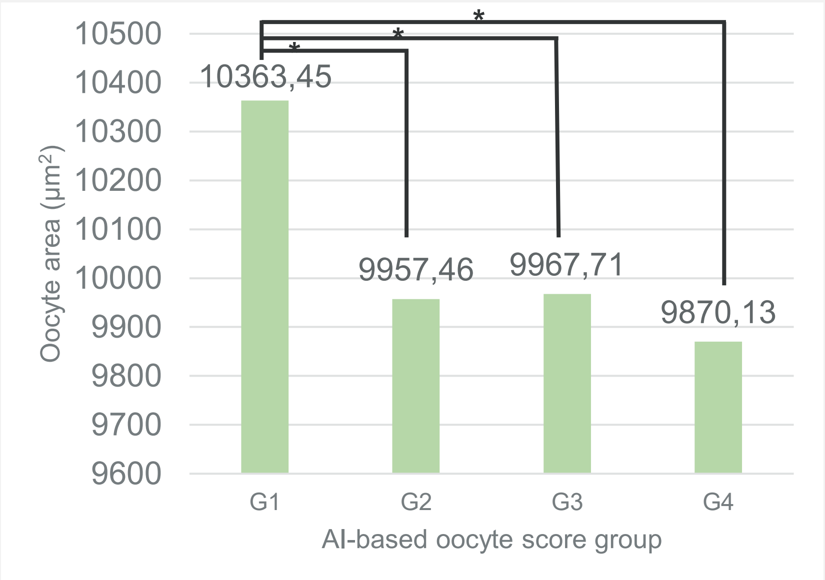

Table 1. Oocyte morphological parameters and dimensional ratios across AI score groups

	ZP	PVS	Oocyte area /PVS	Oocyte area /ZP	PVS/ZP
G1	15,59 ± 2,36	7,99 ± 4,64^{b}	2152,36 ± 2265,10^{c}	684,35 ± 156,44^{d}	0,52 ± 0,31^{e}
G2	16,30 ± 2,57	10,67 ± 5,86^{b}	1172,16 ± 645,19^{c}	628,74 ± 130,57^{d}	0,67 ± 0,39^{e}
G3	16,36 ± 2,47^{a}	10,07 ± 3,95^{b}	1187,014 ± 690,04^{c}	624,03 ± 110.16^{d}	0,64 ± 0,29^{e}
G4	15,75 ± 2,17^{a}	10,52 ± 3,56^{b}	1044,83 ± 376,61^{c}	639.14 ± 101,58^{d}	0,68 ± 025^{e}

Values are expressed as mean ± standard deviation. ZP and PVS measurements are in micrometers (μm); oocyte area is measured in square micrometers (μm²). Different superscript letters indicate statistically significant differences between groups (p < 0.05).

Table 2. Logistic regression for blastocyst development prediction

	OR	95% CI	p-value	AUC (95% CI)
Only morphological parameters				
Oocyte area	0,9997	[0,9995-0,9999]	0,010	0,551 (0,508-0,593)
Mophological parameters + AI score				
Magenta AI Score	1,1067	[1,045-1,1722]	0,001	0,59 (0,548-0,631)

FUNDING

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CONCLUSION

This study confirms that oocyte morphological features, particularly oocyte area, are associated with AI-based scores. However, while oocyte area alone shows limited predictive value for blastocyst development, AI-based scores demonstrate superior performance. These findings support the clinical value of AI-based tools for assessing oocyte quality and predicting developmental potential.

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