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Review Article

Comparison of ICSI Outcomes Between Microfluidic and Conventional Sperm Selection Methods: A Systematic Review and Meta-Analysis

Tohid Rezaei Topraggaleh[1] **Hosein Azizi,**[2,3] **Amir Fattahi**[1] **Ehsan Dadkhah,**[4] **and Behrooz Niknafs**[1,5]

[1]*Department of Reproductive Biology, Faculty of Advanced Medical Sciences, Tabriz University of Medical Sciences, Tabriz, Iran*
[2]*Women's Reproductive Health Research Center, Tabriz University of Medical Sciences, Tabriz, Iran*
[3]*Sarab Faculty of Medical Sciences, Sarab, Iran*
[4]*Department of Mechanical Engineering, University of Tehran, Tehran, Iran*
[5]*Department of Anatomical Sciences, Faculty of Medicine, Tabriz University of Medical Science, Tabriz, Iran*

Correspondence should be addressed to Amir Fattahi; amirfattahi@gmail.com and Behrooz Niknafs; niknafsbeh@yahoo.com

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In recent years, intracytoplasmic sperm injection (ICSI) has become the main selected option in more than half of the assisted reproductive technologies (ARTs) cycles conducted each year. Selecting the most competent sperm cells with highest fertilization potential is crucial to improve clinical outcomes following ICSI procedure. Microfluidic (MF) chips have emerged as a new alternative to conventional methods for selecting high-quality spermatozoa with minimal DNA fragmentation. However, due to the lack of consensus about the effects of MF sperm selection on ICSI outcomes, in the present study, we systematically reviewed and meta-analyzed the impact of MF on fertilization rate (FR), embryo quality (EQ), euploidy rate (ER), pregnancy rate (PR), and live birth rate (LBR) following ART procedures. A systematic comprehensive literature search of the PubMed, Scopus, and Web of Science databases was conducted to determine the impact of MF on fertility outcomes compared to conventional methods. Meta-analysis using random effects model was used to estimate pooled odds ratios (ORs) and weighted mean differences (WMDs) for various ART outcome measures. The search identified 1714 records, of which 21 articles were included in the review. MF significantly increased the rate of fertilization (OR = 1.04; 95% CI: 1.00–1.07; and WMD = 7.24, 95% CI: 6.93, 7.91) and EQ (OR = 1.44; 95% CI: 1.30–1.60), while nonsignificantly increasing the ER (OR = 1.20; 95% CI: 0.92–1.58), PR (OR = 1.09; 95% CI: 0.94–1.25), and LBR (OR = 1.27; 95% CI: 0.99–1.62). Moreover, subgroup analyses revealed that MF chips resulted in significantly higher FR and improved EQ in unexplained infertile and higher PR in male factor infertility patients. These results indicate that couples with a history of male factor or unexplained infertility may benefit from MF–based sperm selection.

Keywords: ART outcomes; DGC; microfluidic chip; sperm selection; swim up

1. Introduction

Recent statistics showed that almost one in six people have experienced infertility during reproductive age, globally [1]. Male factors alone account for 20%–50% of all infertility cases and comprise a wide range of causes including varicocele, hormonal defects, genetic disorders, immunological conditions, genital tract obstruction, and testicular failure [2]. Progress in the field of assisted reproductive technologies (ARTs) provide the opportunity to many of infertile men to have their own biological child [3]. Intracytoplasmic sperm injection (ICSI) is most commonly used in the ART labs due to its higher fertilization rate (FR) and higher number of early cleaving embryos [4]. In this method due to bypassing all in vivo barriers of the female reproductive tract especially cervical mucus, cumulus cells, and zona pellucida, more careful selection of spermatozoa is required [5]. Selecting the most competent sperm cells with highest fertilization potential is crucial to improve clinical outcomes following ICSI procedure [6].

Until now, several sperm selection techniques such as swim up (SU) [7], density gradient centrifugation (DGC) [8], hyaluronic acid binding [9], magnetic activated cell sorting (MACS) [10], motile sperm organelle morphology examination (MSOME) [11], and zeta potential [12] have been employed in ICSI cycles. Among currently available techniques, SU and DGC are a routine part of ART workflows in most infertility treatment cycles [13]. While, longer duration of sperm processing along with centrifugation are major drawbacks of these methods [14]. Moreover, increases in reactive oxygen species (ROS) and DNA fragmentation have been reported following SU and DGC methods [6, 15].

Recently, microfluidic (MF) devices have been attracting great attention for separating highly motile and morphologically normal spermatozoa from the raw semen without centrifugation [16]. Based on sperm characteristics such as self-motility [17], boundary following [18], rheotaxis [19], chemotaxis, and thermotaxis [20], a vast variety of MF devices have been developed. In the growing body of the literature, efficacy of MF chips in selection of high quality spermatozoa with minimum DNA fragmentation has been confirmed compared with SU and DGC [21–24]. However, there is a little information about the clinical outcomes of sperm selection via MF chips and its comparison with routine sperm selection approaches. A recent systematic review and meta-analysis included 13 articles, four of which were not in full text [25]. Therefore, in this study, we aimed to systematically review and meta-analyze all published literature regarding the effects of sperm selection via MF devices and conventional methods on clinical outcomes following ICSI procedure.

2. Methods

This systematic review was conducted in accordance with the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). A protocol for this review study was registered in the International Prospective Register of Systematic Reviews (PROSPERO, ID CRD42024549798).

2.1. Search Strategy. The data for this review were compiled by searching the PubMed, Scopus, and Web of Science databases. The search was conducted until 15 September 2024 with no limitation on the date of publication. The review question was framed using the PICO (population, intervention, control, and outcomes) statements as follows: P: infertile couples underwent ICSI cycles; I: sperm selection by MF; C: sperm selection by conventional methods (SU and DGC); O: FR, embryo quality (EQ), euploidy rate (ER), pregnancy rate (PR), and live birth rate (LBR). Every combination of free and MeSH terms with “AND” and “OR” operators was used for searching. The keywords were “microfluidic,” “microchip,” “Lab-On-A-Chip,” “spermatozoa,” “sperm,” “semen,” and “male gamete.” The Endnote software was utilized to manage the references and duplicate references were removed.

2.2. Inclusion/Exclusion Criteria. The inclusion criteria for the study selection comprised: (a) papers published in English; (b) original and full papers; (c) assessments conducted on human subjects; (d) comparative analyses involving MF chips and conventional sperm selection methods (SU and DGC); (e) study using ICSI. Moreover, the papers with following characteristics were excluded: (a) commentary, abstracts, and theses; (b) diagnostic assessments; (c) studies without ART outcomes; (d) patent application; (e) researches with the primary objective to evaluating sperm quality parameters.

2.3. Data Extraction. Two review authors (Tohid Rezaei Topraggaleh and Ehsan Dadkhah) independently extracted the data using predefined criteria. A comparison was made between the data extracted by the reviewers and discrepancies will be resolved by a third party (Amir Fattahi). The extracted data include: authors, year of publication, location of the study, type of the study, target population, types of the MF chip, type of the conventional sperm selection technique, number of the participants, FR, EQ, ER, PR, and LBR. Studies that lacked clear or extractable raw data were consequently excluded.

2.4. Quality and the Risk of Bias Assessment. Through the Cochrane risk-of-bias instrument [26], it was determined that the quality of the included articles was high. This tool encompassed the following items: generation of the allocation sequence, concealment of the allocation sequence, blinding, attrition and exclusions, other generic sources of bias, biases specific to the trial design, and biases that may be specific to a clinical specialty. The study was categorized as “good” if it was low risk in at least three items, “fair” if it was low risk in two items, and “weak” if it was low risk for no or only one item. Table 1 shows the results of the quality and risk of bias assessment.

2.5. Statistical Analysis. Data analyzed using STATA version 14 (StataCorp, College Station, TX, USA). We calculated odds ratios (ORs) using absolute numbers to estimate pooled ORs including FR, EQ, ER, PR, and LBR. Random effects model was used to estimate pooled ORs. Subgroup analyses were done by the study populations (unexplained infertility, ART failure, unselected patients, male factor infertility, and low fertilization). I^2 was used to assess between studies heterogeneity [46, 47].

3. Results

3.1. Study Selection and Characteristics. In the initial search, 1714 papers were identified including PubMed (405), Scopus (642), Web of Science (632), and other sources (35). Among the identified papers 779 were excluded due to duplication. After screening the title and abstract of the studies, 819 papers were also excluded. 116 articles were assessed for eligibility. After reading full text manuscripts, 21 articles were included in the review considering inclusion/exclusion criteria. The search procedure is illustrated as a flowchart in Figure 1 and characteristics of all included studies are presented in Table 2.

Table 1: Results of quality and risk of bias assessment.

Studies	Random sequence generation	Allocation concealment	Blinding of participants and personnel	Blinding of outcome assessment	Incomplete outcome data	Selective reporting	Overall quality
Yetkinel et al. [27]	L	L	H	L	L	U	Low
Yildiz and Yuksel [28]	L	L	L	L	L	L	Low
Kalyan et al. [29]	L	L	L	L	L	L	Low
Anbari et al. [30]	L	L	H	L	L	H	Low
Ozcan et al. [31]	L	L	L	L	L	L	Low
Leisinger et al. [32]	L	L	H	L	L	H	Moderate
Guler et al. [33]	L	L	H	L	L	L	Low
Quinn et al. [15]	L	L	L	L	L	L	Low
Godiwala et al. [34]	L	L	L	L	L	H	Low
Srinivas et al. [16]	L	L	L	L	L	L	Low
Keskin et al. [35]	L	L	L	L	L	L	Low
Aydın et al. [36]	L	L	H	L	L	L	Low
Mirsanei et al. [37]	L	L	H	L	L	L	Moderate
Kocur et al. [38]	L	L	H	L	L	H	Moderate
Lara-Cerrillo et al. [39]	L	L	H	L	L	L	Moderate
Özaltin et al. [40]	L	L	L	L	L	L	Low
Budak et al. [41]	L	L	H	L	L	L	Moderate
Zaha et al. [42]	L	L	L	L	L	L	Low
Godiwala et al. [43]	L	L	L	L	L	L	Low
Banti et al. [44]	L	L	H	L	L	L	Moderate
Escudé-Logares et al. [45]	L	L	L	L	L	L	Low

Note: L, low risk; H, high risk; U, unknown.

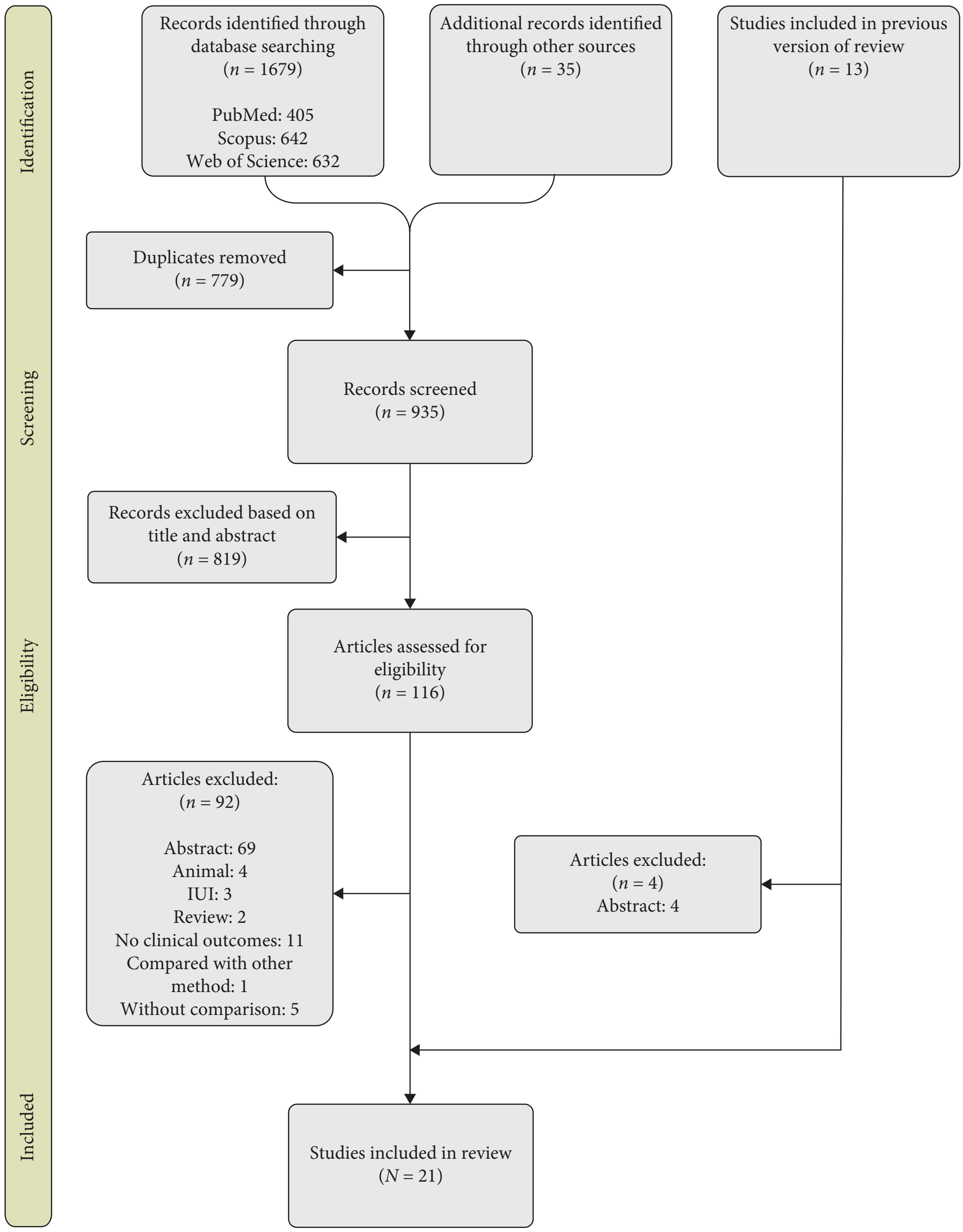

Figure 1: PRISMA flowchart of literature review and study selection.

3.2. Meta-Analysis and Subgroup Meta-Analysis

3.2.1. FR. A random-effects model was used to evaluate FR following sperm selection via MF and conventional methods. A forest plot was carried out to estimate the pooled analysis of the included studies (Figure 2). The meta-analysis of the pooled OR indicated that MF sperm selection significantly increased the FR compared to conventional sperm selection methods (OR = 1.04; 95% CI: 1.00–1.07, $p = 0.206$, $I^2 = 30.6\%$).

Regarding the mean value of the FR, MF sperm selection significantly improved the FR than conventional methods (weighted mean difference (WMD) = 7.24, 95% CI: 6.93, 7.91; $p < 0.001$, $I^2 = 95.3\%$; Figure 3). Moreover, mean value of FR was significantly improved in MF chips compared to conventional methods in unexplained infertile and patients with history of lower fertilization, respectively (WMD = 5.98, 95% CI: 5.36, 6.61; $p = 0.037$, $I^2 = 69.6\%$; WMD = 10.40, 95% CI: 9.60, 11.20; $p = 0.004$, $I^2 = 88.2\%$). Regarding microchip type, FR favored the ZyMōt multi over DGC sperm selection technique (OR = 1.05; 95% CI: 1.00–1.11, $p = 0.087$, $I^2 = 59.1\%$; Supporting Information 1: Figure S1). However, there were no significant

Table 2: Characteristics of all studies included in the systematic review.

Author and Year	Country	Study design	Target population	Sample size of control	Sample size of MF	Type of control	Type of MF	Clinical outcomes
Yetkinel et al. (2019) [27]	Turkey	Prospective randomized controlled trial	Unexplained infertility	61	61	SU	ZyMōt	FR, EQ, PR, and LBR
Yildiz and Yuksel (2019) [28]	Turkey	Prospective randomized controlled trial	Unexplained infertility	312	116	DGC	ZyMōt Multi	FR and PR
Kalyan et al. (2019) [29]	Turkey	Prospective randomized controlled trial	Unselected infertile	81	81	SU	ZyMōt Multi	EQ, PR, and LBR
Anbari et al. (2021) [30]	Iran	Prospective randomized controlled trial	Unexplained infertility	50	45	SU	MSS	FR, EQ, and PR
Ozcan et al. (2021) [31]	Turkey	Retrospective cohort study	Male factor infertility	90	91	DGC	ZyMōt	PR
Leisinger et al. (2021) [32]	USA	Prospective randomized controlled trial	Unselected infertile	86	86	SU DGC	ZyMōt	FR, ER, and PR
Guler et al. (2021) [33]	Turkey	Prospective randomized controlled trial	Male factor infertility	22	22	DGC	ZyMōt Multi	EQ
Quinn et al. (2022) [15]	USA	Prospective randomized controlled trial	Unselected infertile	194	192	DGC	ZyMōt	FR, EQ, and PR
Godiwala et al. (2022) [34]	USA	Retrospective cohort study	Low fertilization rate	88	88	DGC	ZyMōt Multi	FR and ER
Srinivas et al. (2022) [16]	India	Prospective randomized controlled trial	ART failure	151	180	DGC	Qualis	PR
Keskin et al. (2022) [35]	Turkey	Retrospective cohort study	Male factor infertility	151	92	DGC	ZyMōt Multi	EQ, ER, and LBR
Aydın et al. (2022) [36]	Turkey	Prospective randomized controlled trial	Male factor infertility	64	64	SU	ZyMōt	FR, EQ, PR, and LBR
Mirsanei et al. (2022) [37]	Iran	Prospective randomized controlled trial	Low fertilization rate	25	25	DGC	ZyMōt Multi	EQ
Kocur et al. (2023) [38]	USA	Retrospective cohort study	ART failure	57	57	DGC	ZyMōt Multi	FR, ER, PR, and LBR
Lara-Cerrillo et al. (2023) [39]	Spain	Retrospective cohort study	Male factor infertility	28	28	SU DGC	ZyMōt	FR, EQ, PR, and LBR
Özaltin et al. (2023) [40]	Turkey	Prospective randomized controlled trial	Unselected infertile	111	102	SU	ZyMōt	EQ, PR, and LBR
Budak et al. (2023) [41]	Turkey	Retrospective cohort study	ART failure	35	35	SU	ZyMōt	PR
Zaha et al. (2023) [42]	Romania	Retrospective cohort study	Unselected infertile	119	120	DGC	ZyMōt	FR and PR
Godiwala et al. (2024) [43]	USA	Prospective randomized controlled trial	Unselected infertile	106	106	DGC	ZyMōt multi	FR, ER, PR, and LBR
Banti et al. (2024) [44]	UAE	Retrospective cohort study	ART failure	53	53	DGC	ZyMōt multi	FR
Escudé-Logares et al. (2024) [45]	Spain	Retrospective cohort study	ART failure	87	102	DGC	ZyMōt	FR

Note: ZyMōt, fertile chip; ZyMōt Multi, fertile plus.
Abbreviations: DGC, density gradient centrifugation; EQ, embryo quality; ER, euploidy rate; FR, fertilization rate; LBR, live birth rate; MSS, microfluidic sperm sorting; PR, pregnancy rate; SU, swim up.

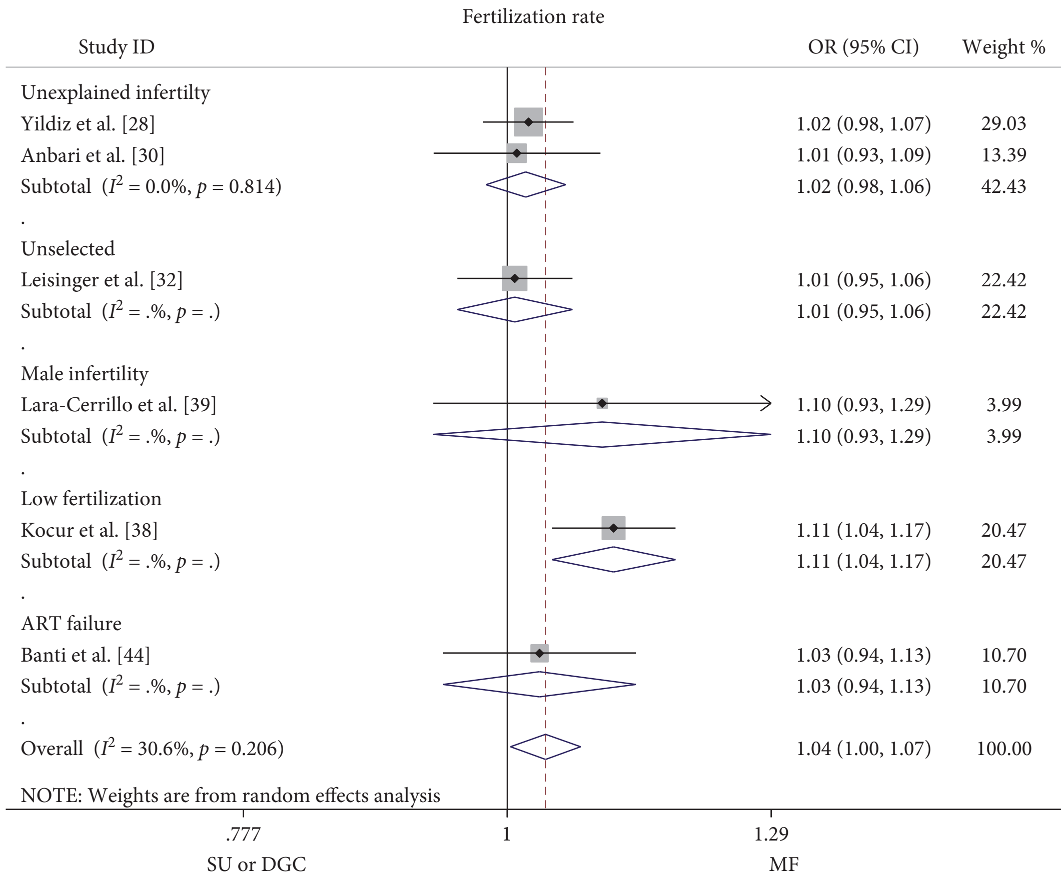

FIGURE 2: Meta-analysis of the fertilization rate by various target groups including unexplained, unselected, male factor, low fertilization, and ART failure.

differences in FR between ZyMōt and DGC sperm selection methods (Supporting Information 2: Figure S2).

3.2.2. EQ. Out of the included studies, 10 papers reported the EQ following sperm selection with MF and conventional methods. In five out of these 10 papers, the number of high quality embryos was expressed per MII oocyte. The pooled estimate showed that MF approach significantly yielded more high quality embryos than conventional sperm selection methods (OR = 1.44, 95% CI: 1.30, 1.60; $p = 0.045$, $I^2 = 59.0\%$). In subgroup analysis EQ was significantly improved in MF sperm selection group compared to SU or DGC in unexplained (OR = 1.32, 95% CI: 1.19, 1.48; $p = 0.088$, $I^2 = 65.7\%$) and male factor (OR = 1.68, 95% CI: 1.20, 2.34; $p = 0.149$, $I^2 = 51.9\%$) infertile patients (Figure 4).

3.2.3. ER. ER was displayed in five of included studies. In three of these studies, ER was measured per biopsied embryos. Random-effect model showed that the ER was not statistically significant between MF and conventional sperm selection methods (OR = 1.20, 95% CI: 0.92, 1.58; $p < 0.001$, $I^2 = 87.1\%$). Moreover, in subgroup analysis, due to limited number of studies, there were no significant differences between both sperm selection methods regarding causes of infertility (Figure 5).

3.2.4. PR. Fourteen studies reported PRs following sperm selection by MF and conventional techniques. A random-effect model analysis showed that the overall PR was not significantly affected by the sperm selection methods (OR = 1.09, 95% CI: 0.94, 1.25; $p = 0.010$, $I^2 = 53.2\%$; Figure 6). However, rate of the pregnancy was significantly improved in MF chips than conventional techniques in the couples with male factor infertility (OR = 1.45, 95% CI: 1.04, 2.02; $p = 0.240$, $I^2 = 29.9\%$). There were no significant differences in PR between MF and conventional sperm selection methods based on history of infertility including unexplained, low fertilization, and ART failure. Moreover there were no significant differences in PR following sperm selection with ZyMōt and ZyMōt Multi chips with either SU or DGC selection methods (Supporting Information 3: Figure S3, Supporting Information 4: Figure S4, and Supporting Information 5: Figure S5).

3.2.5. LBR. A comprehensive analysis of eight papers assessed LBRs following sperm selection using MF and conventional techniques. The overall estimate did not favor either of MF and conventional sperm selection methods (OR = 1.27, 95% CI: 0.99, 1.62; $p = 0.059$, $I^2 = 48.6\%$; Figure 7). Subgroup analysis of samples based on causes of infertility indicated that MF sperm selection methods represented no significant effects on LBRs compared to conventional methods. Moreover, analysis based on the type of MF chips demonstrated no significant differences between MF and conventional methods in terms

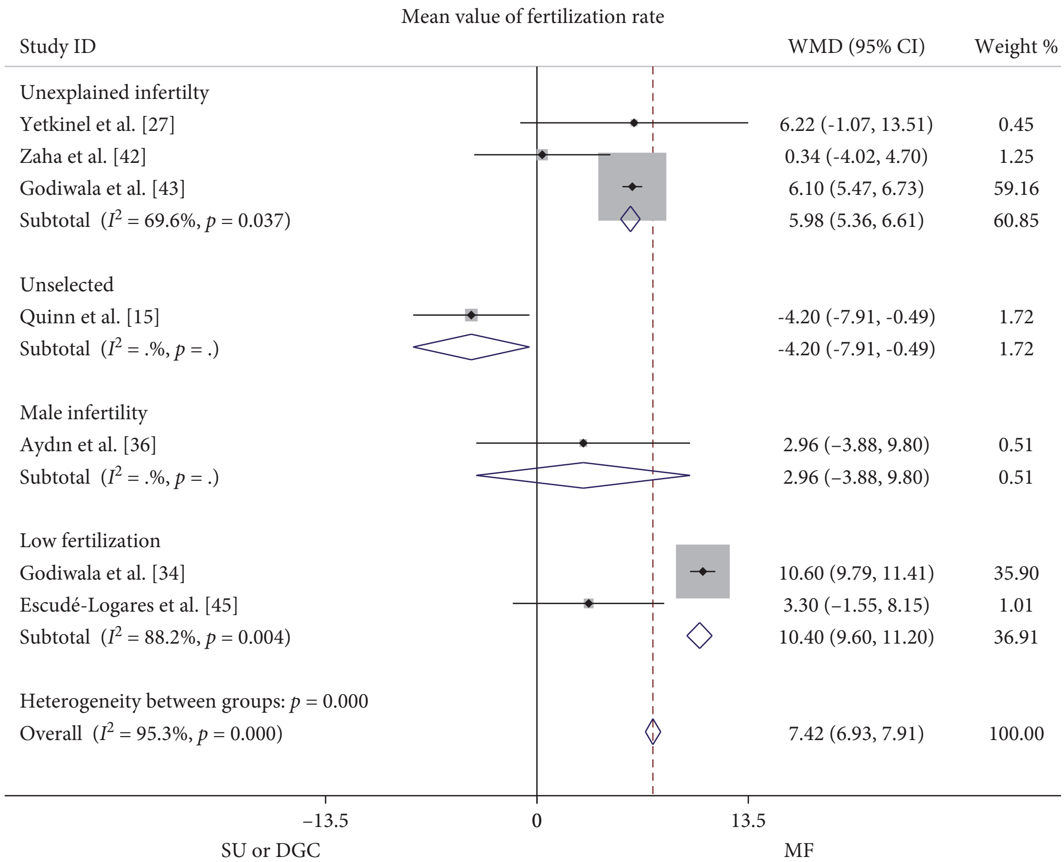

FIGURE 3: Meta-analysis of mean value of the fertilization rate by various target groups including unexplained, unselected, male factor, and low fertilization.

of LBR (Supporting Information 6: Figure S6 and Supporting Information 7: Figure S7).

4. Discussion

MF-based sperm selection provides rapid isolation of poor semen samples with low morphological abnormality, improved motility, and DNA integrity [33]. The basic idea of sperm selection by MF system is to closely imitate natural sperm selection of female reproductive tract [40]. This technique has begun to be commonly applied in ART program. However, laboratory outcomes of sperm selection using MFs are poorly documented.

In this paper, we systematically reviewed and meta-analyzed the effects of sperm selection methods including MF and conventional techniques on embryological outcomes in patients undergoing ICSI procedure. The MF sperm selection devices demonstrated significantly higher FR and mean value of fertilization compared to conventional selection methods. Indeed, FR can be affected by several factors such as sperm parameters, oocyte quality, culture condition, ICSI technique, and operator [48]. From male viewpoint, improvements in FR are closely associated with sperm quality [31]. In addition to paternal DNA, sperm also deliver oocyte activation factors and centriole into the oocyte which are essential for fertilization and early embryonic development [49]. Sperm progressive motility and DNA integrity are recognized in the literature as more robust predictors of ART outcomes [50, 51]. The ability to isolate sperm with increased progressive motility and decreased DNA fragmentation is a key advantage of MF chips over conventional selection methods [33]. The higher FR observed after MF-based sperm selection is likely due to lower DNA fragmentation and increased progressive motility of spermatozoa compared to conventional methods. Furthermore, subgroup analysis demonstrated that MF chips significantly increased FR compared to conventional methods in couples with a history of low fertilization and unexplained infertility. This observation is supported by Mirsanei et al.'s [37] data which showed a significant increase in PLCZ1 gene expression after MF sperm selection compared to density gradient.

According to results of EQ, overall meta-analysis showed that MF selection method yielded significantly higher number of high-grade embryos compared to SU or DGC. Moreover, in subgroup analysis, we found that MF chips resulted in a significantly higher number of good-quality embryos compared to conventional methods in unexplained and male factor infertile couples. The success in obtaining excellent-quality embryos following MF based sperm selection could be attributed to lower exposure of the sperm cells to oxidant factors [40]. In conventional sperm selection methods, the shearing forces induced on sperm cells during centrifugation and prolonged processing time cause an excessive production of ROS [52]. Preparation techniques involving centrifugation are associated with a sudden burst

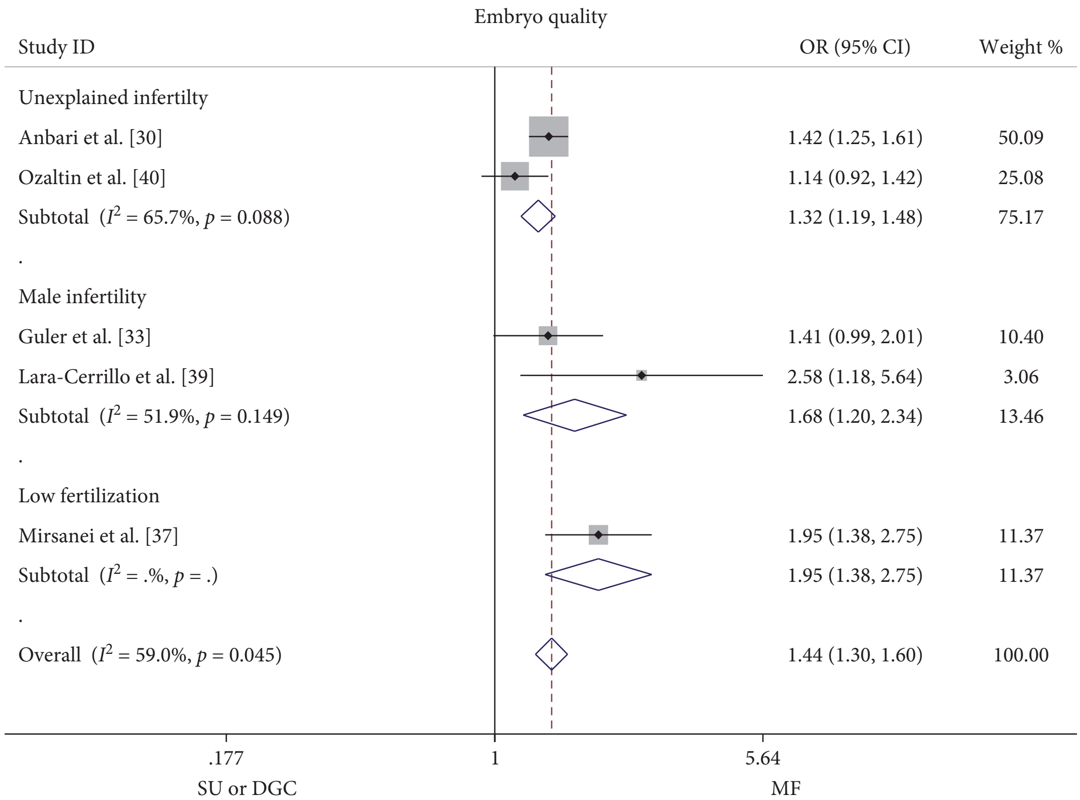

FIGURE 4: Meta-analysis of embryo quality by various target groups including unexplained, male factor, and low fertilization.

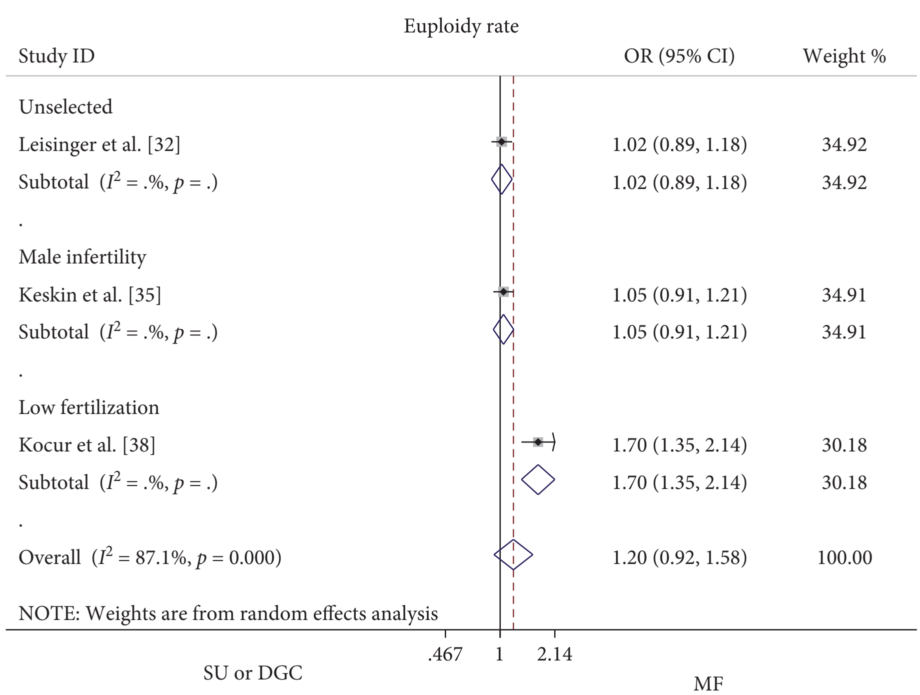

FIGURE 5: Meta-analysis of euploidy rate by various target groups including unselected, male factor, and low fertilization.

of ROS production and impaired DNA integrity [52]. In the growing body of the literature, a strong relationship between paternal DNA integrity and EQ has been reported [53–56]. Therefore, increasing EQ following ICSI with MF selected spermatozoa could be attributed to decreased sperm ROS and improved DNA integrity.

In addition to FR and EQ, ER is also a crucial determinant of ART success [57]. Although ERs of biopsied embryos

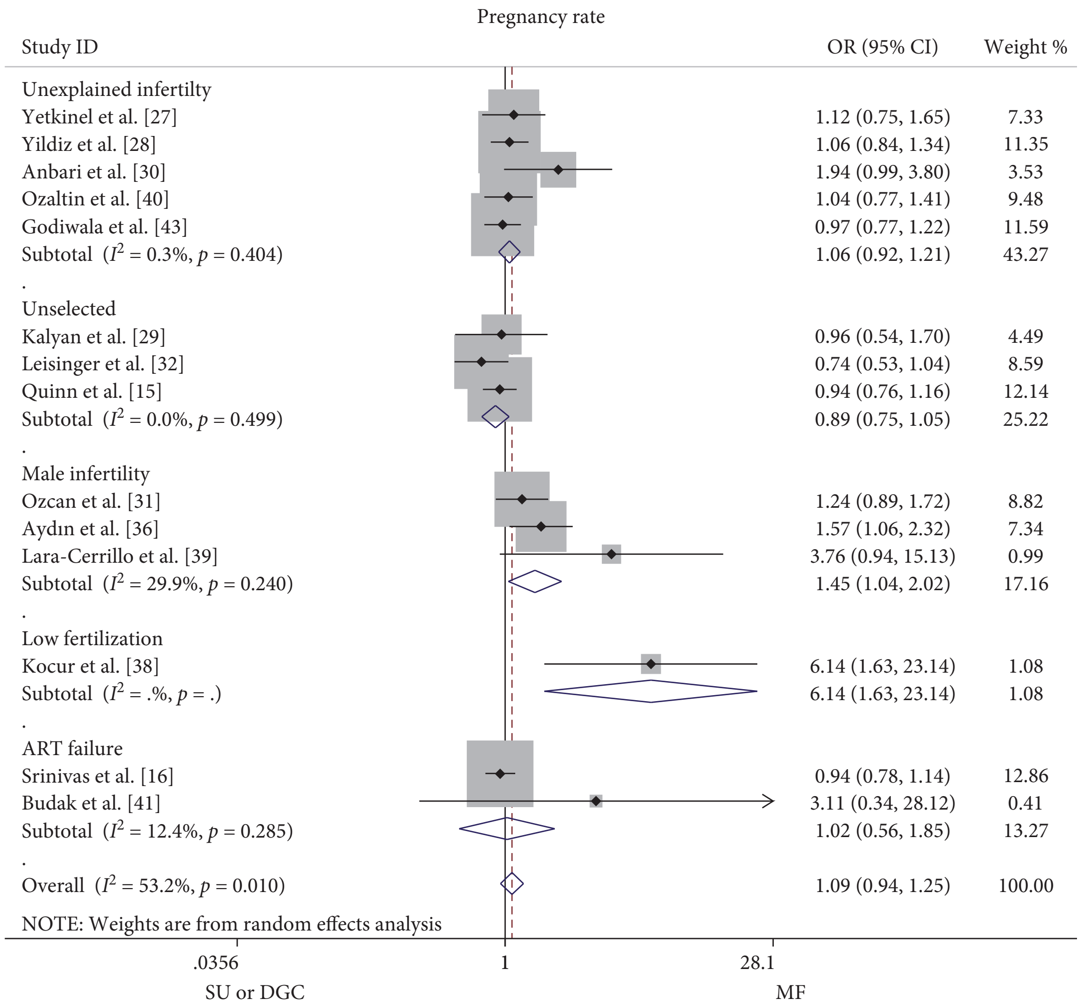

Figure 6: Meta-analysis of pregnancy rate by various target groups including unexplained, unselected, male factor, low fertilization, and ART failure.

tended to be higher with MF-selected sperm, no statistically significant differences were observed between MF and conventional methods. While female factors play a significant role, male parameters, including sperm quality and DNA integrity, contribute minimally to the incidence of embryo aneuploidy [58–60]. It is well established that the molecular mechanisms responsible for DNA repair exist within the mature oocyte and these mechanisms restore DNA integrity that may be present due to damaged spermatozoa [32, 61, 62]. Therefore, it can be assumed that oocyte repair mechanisms appear adequate to counteract DNA damage and prevent embryo aneuploidy following conventional sperm selection techniques [32]. Moreover, to potentially obtain more definitive results concerning ER, a broader dataset is needed.

Furthermore, we did not find significant differences in pregnancy and LBRs following sperm selection using MF and conventional sperm selection techniques. While in subgroup analysis, PR were significantly higher in male factor couples compared with conventional methods. Pregnancy and live birth are complex processes influenced by numerous variables. The role of male factors in pregnancy and LBRs is not negligible [63]. However, female parameters, including age, number of transferred embryos, uterine receptivity, hormonal balance, and lifestyle, significantly influence these outcomes [64–66]. While MF sperm selection methods may improve certain sperm parameters such as DNA integrity and progressive motility current assessment methods might not fully capture all relevant aspects of sperm quality.

Based on the shortcomings identified in the current body of literature, we suggest some directions for future research. First, in all of the published papers self-motility–based MF chips such as ZyMōt, ZyMōt Multi, and Qualis were compared with conventional selection methods. However, other characteristics of mature spermatozoa including, rheotaxis, chemotaxis, thermotaxis, and boundary following were not considered. Improvement of DNA integrity in sperm selection based on rheotaxis and boundary following have been reported previously [18, 21, 67, 68]. Thus, evaluation of ART outcomes following sperm selection based on rheotaxis and boundary following properties of sperm is recommended in future works. Second, based on the results of subgroup analysis, MF sperm selection did not demonstrate an advantage over conventional methods in unselected infertile patients. However, couples with male factor or unexplained infertility may benefit from MF sperm selection,

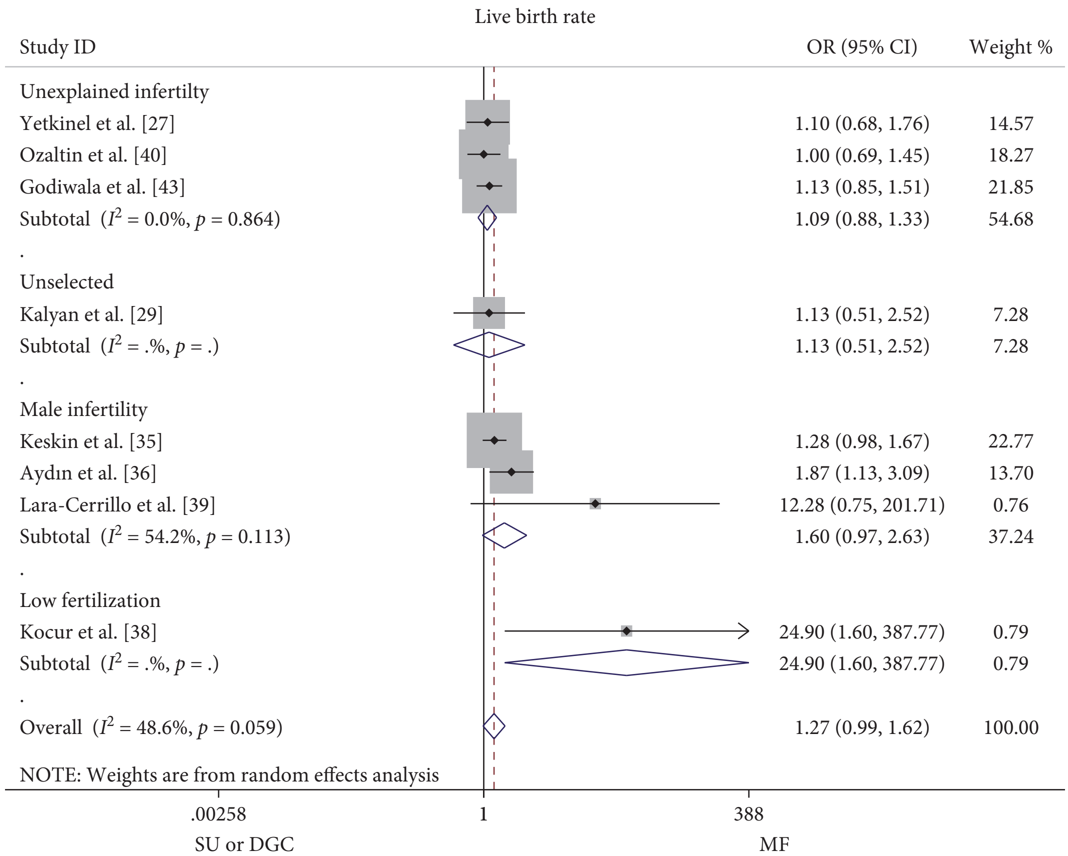

FIGURE 7: Meta-analysis of live birth rate by various target groups including unexplained, unselected, male factor, and low fertilization.

potentially due to improved FRs, EQ, and PRs. Therefore, appropriate patient selection is critical for ART success before utilizing any sperm processing technique. Finally, while the single center design of all the studies may have been advantageous with respect to adherence to study protocols, further multicenter randomized clinical trial may result greater generalizability of the findings, and thus, may provide a more accurate depiction "real world" application of MF sperm selection technique.

5. Conclusion

Based on current literature, we conclude that MF sperm selection resulted in a higher FR and improved EQ compared to conventional methods. While, overall ER, PR, and LBR were not affected by the sperm selection methods, PR was significantly higher in MF chips compared to SU or DGC in couples with a history of male factor infertility. Furthermore, subgroup analyses revealed that MF chips resulted in higher FR and improved EQ in both unexplained and male factor infertility patients. These findings suggest that couples with a history of male factor or unexplained infertility may benefit from MF-based sperm selection.

Data Availability Statement

The data are available upon request.

Conflicts of Interest

The authors declare no conflicts of interest.

Author Contributions

T. R. T.: conceptualization, investigation, methodology, writing–original draft of paper. H. A.: statistical analysis, methodology. A. F.: project administration, supervision, writing–review and editing. E. D.: writing–original draft, writing–review and editing. B. N.: conceptualization, project administration, supervision, writing–review and editing.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.
Supporting Information 1. Figure S1: Meta-analysis of fertilization rate using ZyMōt Multi and DGC.

Supporting Information 2. Figure S2: Meta-analysis of mean value of fertilization rate using ZyMōt and DGC.

Supporting Information 3. Figure S3: Meta-analysis of pregnancy rate using ZyMōt and Swim up.

Supporting Information 4. Figure S4: Meta-analysis of pregnancy rate using ZyMōt and DGC.

Supporting Information 5. Figure S5: Meta-analysis of pregnancy rate using ZyMōt Multi and DGC.

Supporting Information 6. Figure S6: Meta-analysis of live birth rate using ZyMōt and Swim up.

Supporting Information 7. Figure S7: Meta-analysis of live birth rate using ZyMōt Multi and DGC.

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