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Full length article

Fertility outcomes after hysteroscopic niche resection compared with expectant management in women with a niche in the uterine cesarean scar

Chuqing He [a,b], Wei Xia [a,b], Li Yan [a,b], Yang Wang [a,b], Yuan Tian [a,b], Ben W. Mol [c,d], Jian Zhang [a,b,*], JAF Huirne [e]

[a] Department of Obstetrics and Gynecology, International Peace Maternity and Child Health Hospital, School of Medicine, Shanghai Jiaotong University, Shanghai, China
[b] Shanghai Key Laboratory Embryo Original Diseases, Shanghai, China
[c] Department of Obstetrics and Gynecology, Monash University, 246 Clayton Road, Clayton 3168, Victoria, Australia
[d] Aberdeen Centre for Women's Health Research, University of Aberdeen, Aberdeen, UK
[e] Department of Obstetrics and Gynecology, Amsterdam Reproduction and Development Research Institute, Amsterdam University Medical Centre, Location AMC and VUmc, Amsterdam, The Netherlands

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ABSTRACT

Objective: To determine whether hysteroscopic niche resection (HNR) and expectant management are suitable in women with fertility desire and a niche with a residual myometrium thickness (RMT) ≥ 2.5 mm.
Study design: This retrospective cohort study was conducted at International Peace Maternity and Child Health Hospital, School of Medicine, Shanghai Jiaotong University, Shanghai, China between September 2016 and December 2021. We reported the fertility outcomes between women (with fertility desire and a niche with RMT ≥ 2.5 mm) who received HNR or expectant management.
Results: We studied 166 women, of whom 72 accepted HNR and 94 accepted expectant management. The HNR group included more symptomatic women, in terms of postmenstrual spotting or infertility. No differences were found regarding niche measures before treatment. The live birth rate was comparable in both groups (HNR versus expectant management as 55.5% versus 45.7%, risk ratio = 1.48, 95% Cl 0.80–2.75, p = 0.21). The pregnancy rate was higher in HNR group than that in expectant management group (n = 72.2% versus n = 56.4%, risk ratio = 2.01, 95% CI 1.04–3.88, p = 0.04). In a subgroup of women with infertility before entry in the study, HNR resulted in a significant higher live birth rate (p = 0.04) and pregnancy rate (p = 0.01).
Conclusion: In women with infertility with a symptomatic niche with RMT ≥ 2.5 mm, HNR may be superior to expectant management. This retrospective cohort biased selection against a randomized study, our results still need to be validated in the future with larger clinical multicenter randomized controlled trials.

Introduction

Over the past few decades, the rate of cesarean section (CS) has increased worldwide [1]. In China, it increased from 28.8% to 36.7% between 2008 and 2018 [2]. Niche, a long-term complication associated with CS, is defined as a discontinuity of the myometrium at the site of the cesarean scar of at least 2 mm deep [3]. It is commonly associated with postmenstrual spotting, chronic pelvic pain and secondary infertility. It also increases the risk of complications during subsequent pregnancy, including cesarean scar pregnancy (CSP), placenta praevia, postpartum hemorrhage and uterine rupture [4–6]. Reported incidence of a niche ranges between 19.4% and 88% when assessed by different methods including ultrasound, sonohysterography, magnetic resonance imaging (MRI) and hysteroscopy [7].

Various treatments are reported to treat niche related symptoms. So far, there is no international acknowledged guideline for niche treatments. In contrast to laparoscopic or vaginal surgery, a hysteroscopic niche resection (HNR) does not restore the anatomy [8]. Although HNR is considered as the least invasive surgical approach in women with a relatively small niche (defined as a niche with residual myometrium

Abbreviations: HNR, hysteroscopic niche resection; RMT, residual myometrium thickness; CS, cesarean section; CSP, cesarean scar pregnancy; PROM, premature rupture of fetal membrane; MRI, magnetic resonance imaging; RCT, randomized controlled trial.

* Corresponding author at: Department of Obstetrics and Gynecology, International Peace Maternity and Child Health Hospital, School of Medicine, Shanghai Jiaotong University, 910 Hengshan Road, Xuhui District, Shanghai, China.
E-mail address: zhangjian_ipmch@sjtu.edu.cn (J. Zhang).

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thickness (RMT) ≥ 2.5 mm [7], there has been considerable controversy about whether this method is suitable for women with fertility desire [4,9–11].

Several studies suggested that a HNR could remove the local inflammatory response from deposited menstrual blood at the uterine cesarean scar, reduce the interference on uterine mucus and sperm transport, thus benefiting embryo implantation [7,12].

Moreover, in comparison to expectant management, the effect of HNR remains unclear. Up to now, there was only one randomized controlled trial (RCT) including 61 women with infertility and follow-up at 12 months, indicated a higher clinical pregnancy rate in the group of patients who had hysteroscopic surgery when compared with expectant management [13].

Given the current lack of comparative studies, we performed this retrospective study to determine whether HNR and expectant management are suitable in women with fertility desire and a niche with RMT ≥ 2.5 mm.

Material and methods

Study design

A single-center retrospective cohort study was performed in International Peace Maternity and Child Health Hospital affiliated to School of Medicine, Shanghai Jiaotong University, Shanghai, China. All eligible patients attending our department between September 2016 and December 2021 for HNR or expectant management were enrolled in our study.

Participants

Our hospital established an out-patient service for niche to ensure that women diagnosed with a niche get optimal consultation and treatment. A database was established at this out-patient service.

The inclusion criteria were as follows: with active desire to conceive; with a history of CS; postmenstrual spotting after at least one previous CS; chronic pelvic pain; infertility (defined as failure to conceive after one year of regular intercourse without contraception); a niche (depth ≥ 2 mm) with RMT ≥ 2.5 mm on MRI before HNR or expectant management.

For women with infertility, additional inclusion criteria was that women had accepted infertility tests (including physical examination, ultrasound, hysterosalpingogram, blood test and semen analysis) to excluded infertility factors other than niche.

The exclusion criteria were as follows: prolonged menstrual bleeding before CS; other diseases that may lead to irregular bleeding such as endometrial polyps, endometrial hyperplasia, gynecological tumors and uterine fibroids; presence of an intrauterine device; tubal dysfunction.

We collected baseline characteristics including age, reproductive history, infertility history, menstruation duration, uterine position, RMT and findings of niche during MRI before HNR or expectant management. Women were followed up for fertility outcomes till September 2022.

Outcomes

Primary outcomes were the live birth rate (defined as the birth rate of a living neonate) and pregnancy rate (defined as the rate of women who had a positive pregnancy test or serum human chorionic gonadotropin level of >5mIU/L).

Secondary outcomes were obstetric complications and adverse pregnancy outcomes. Obstetric complications included uterine rupture, intrapartum/postpartum hemorrhage, placenta previa, preterm delivery and premature rupture of fetal membrane (PROM). Adverse pregnancy outcomes included miscarriage (defined as a spontaneous intrauterine pregnancy loss diagnosed by ultrasound or by histology), tubal pregnancy (defined as an embryo implanted the fallopian tube) and cesarean scar pregnancy (defined as embryo implantation in close contact with the niche [6]).

Secondary outcomes also included mode of conception (natural or assisted reproductive therapy) and time to pregnancy (the time between the date that women consulted our out-patient service for niche because of fertility desire and the niche was diagnosed on MRI to the date of the last menstruation before subsequent pregnancy).

Interventions

HNR group

Women in this group accepted HNR regardless of niche symptoms. Procedure was performed according to a standardized protocol described by Vervoort A et al. [14]. The cervix was dilated up to Hegar 9. Then a resectoscope (Ch. 26 model WA22061 with a 12° optic 22001A) equipped with a 3-mm-deep and 5-mm-wide loop (Olympus, Germany) was placed. 0.9% NaCl under 100 mmHg intrauterine pressure was used as distention medium. The niche and its features were registered (presence of dome-shaped scar defect, of nodule-like endometrial hyperplasia, of vascularity, valve-like motion or a very high edge). We collected endometrium for histological examination. Thereafter a cutting loop was used to resect distal rim of the niche and coagulate the surface of the niche [3]. The procedure was suspended if any complications occurred, such as bladder injury and perforation.

Expectant management group

The niche was evaluated by MRI. Women with postmenstrual spotting in this group received diagnostic hysteroscopy to exclude any intrauterine pathology.

Statistical analysis

All data were analyzed by IBM SPSS 23 (SPSS Inc., Chicago, IL, USA) and the survival package in R Version 4.0.2 (R Project for Statistical Computing, Vienna, Austria) was used for drawing plots of survival analysis. The Kaplan-Meier method was used to compute cumulative pregnancy rate curves (1-survival function), and the differences were compared by log-rank test. All tests were performed two sided and $p < 0.05$ was considered as statistically significant. The magnitude of statistical significance was expressed with risk ratio and 95% confidence intervals (CI). For continuous variables, if normally distributed, student *t* test was used, otherwise Mann-Whitney *U* test was used. For categorical variables, χ^2 test was used. The date of entry was the date that women consulted our out-patient service for niche because of fertility desire and the niche was diagnosed on MRI. The last day of analysis was the date of the delivery or the last follow-up visit in women who failed to become pregnant. A univariate and multivariate Cox proportional hazards regression model in an enter fashion was processed to identify predictors of pregnancy according to age (years, < 35 versus ≥ 35), numbers of CS (1 versus ≥ 2), infertility before entry in the study (with versus without), menstruation duration before treatment (days, ≤ 8 versus 8–14 versus ≥ 15) and management (HNR versus expectant management).

Results

Participants

Between September 2016 and December 2021, 191 women with a niche (RMT ≥ 2.5 mm) and an active desire to conceive accepted HNR or expectant management. 25 women were excluded because of having other uterine pathologies, tubal dysfunction, being not available when contacted or having inserted mirena. (Fig. 1).

From the 166 included women, 72 received HNR and 94 accepted expectant management.

Two groups were comparable regarding age, reproductive history, uterus position, RMT and findings of niche during MRI (Table 1).

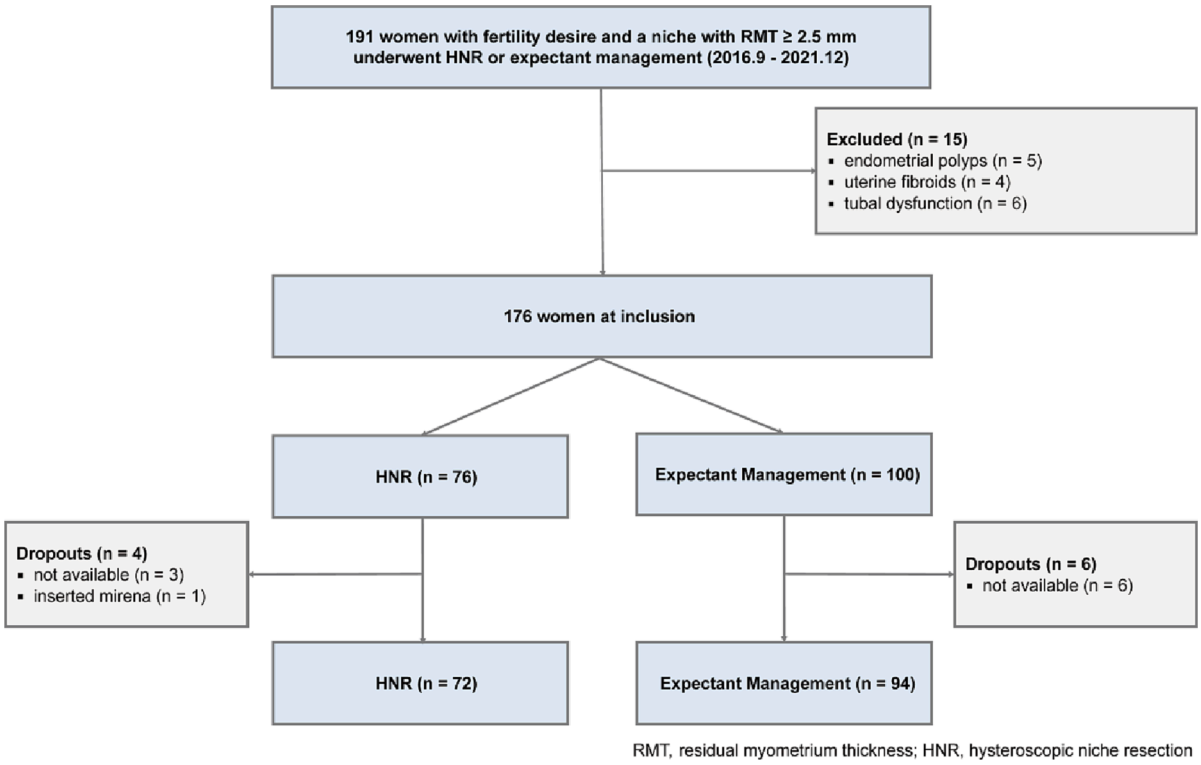

Fig. 1. Flow chart.

Table 1
Comparison of baseline characteristics.

Mean ± SD/M (Q1 - Q3)/No. (%)	HNR group (n = 72)	Expectant management group (n = 94)	P value
Age (year)	33.5 ± 3.6	33.5 ± 3.8	0.60
Gravidity	2 (1 - 3)	2 (1 - 3)	0.06
Parity	1 (1 - 1)	1 (1 - 1)	0.19
Number of caesarean sections			
1	62 (86.1)	86 (91.5)	0.27
≥2	10 (13.9)	8 (8.5)	
Previous cesarean scar pregnancy			
No	70 (97.2)	90 (95.7)	0.93
Yes	2 (2.8)	4 (4.3)	
Infertility * before entry in the study			
Without	36 (50.0)	75 (79.8)	< 0.01
With	36 (50.0)	19 (20.2)	
Retroflexion of uterus			
No	35 (48.6)	46 (48.9)	0.97
Yes	37 (51.4)	48 (51.1)	
Menstruation duration (day)	10 (10 - 14)	8 (7 - 10)	< 0.01
RMT (mm)	4 (3 - 5)	4 (3 - 5)	0.75
Findings of niche during MRI (mm)			
Length	6 (5 - 9)	6 (4 - 7)	0.16
Width	12 (8 - 14)	11 (7 - 13)	0.16
Depth	5 (4 - 7)	5 (4 - 7)	0.86

SD, standard deviation; M (Q1 - Q3), median (first quartile - third quartile); HNR, hysteroscopic niche resection; RMT, residual myometrium thickness; MRI, magnetic resonance imaging.
*Failure to conceive after one year of regular intercourse without contraception.

However, menstruation duration was significantly longer in HNR group compared to expectant management group (10 (10-14) versus 8 (7-10) days, respectively, $p < 0.01$). In HNR group, 50.0% (36/72) of women had infertility before entry in the study, while 20.2% (19/94) of women had infertility before entry in the study in expectant management group ($p < 0.01$).

Fertility outcomes

The fertility outcomes are shown in Table 2.

The live birth rate was comparable in both groups (HNR versus expectant management as 55.5% versus 45.7%, risk ratio = 1.48, 95% CI 0.80–2.75, p = 0.21). In HNR group, 48.6% (35/72) of women had a live birth via natural conception, compared to 40.4% (38/94) in expectant management group. The live birth rate via assisted reproductive therapy was small in both groups (6.9% versus 5.3%).

The pregnancy rate was higher in HNR group compare to that in expectant management group (n = 72.2% versus n = 56.4% respectively, risk ratio = 2.01, 95% CI 1.04–3.88, p = 0.04). The HNR group also achieved a higher pregnancy rate via natural conception (n = 65.3% versus n = 51.1% respectively, p = 0.07).

The survival curve showed a higher cumulative pregnancy rate in HNR group (87.4%) than that in expectant management group (62.5%) (Fig. 2 - A).

No significant differences were found regarding miscarriage and tubal pregnancy between the two groups. In both groups, one CSP was reported. The two CSP patients underwent suction curettage under ultrasonography after uterine arterial embolization.

Among 40 live births in HNR group, we observed 3 cases of preterm delivery (2 women delivered at 36.8 weeks and 1 women delivered at 35.7 weeks), 2 cases of marginal placenta previa, 1 case of complete placenta previa accompanied by postpartum hemorrhage due to placental factors and uterine atony and 2 cases of PROM.

Among 43 live births In expectant management group, there existed 2 cases of preterm delivery (1 women delivered at 36.7 weeks and 1 women delivered at 35.4 weeks), 2 cases of marginal placenta previa (1 combined with postpartum hemorrhage due to placental factors) and 2 cases of PROM.

Table 2
Comparison of fertility outcomes.

No. (%)	HNR group (n = 72)	Expectant management group (n = 94)	RR [95% CI]	P value
Live birth rate	40 (55.5)	43 (45.7)	1.48 (0.80 - 2.75)	0.21
Mode of conception of live birth				
natural conception	35 (48.6)	38 (40.4)	1.40 (0.75 - 2.59)	0.29
conception after assisted reproductive therapy	5 (6.9)	5 (5.3)	1.33 (0.37 - 4.78)	0.66
Obstetric complication				
Preterm birth	3 (7.5)	2 (4.6)	1.66 (0.26 - 10.50)	0.59
Placenta previa	3 (7.5)	2 (4.6)	1.66 (0.26 - 10.50)	0.59
Postpartum hemorrhage	1 (2.5)	1 (2.3)	1.07 (0.07 - 17.81)	0.96
PROM	2 (5.0)	2 (4.6)	1.08 (0.15 - 8.05)	0.94
Pregnancy rate	52 (72.2)	53 (56.4)	2.01 (1.04 - 3.88)	0.04
Mode of conception of pregnancy				
natural conception	47 (65.3)	48 (51.1)	1.80 (0.96 - 3.39)	0.07
conception after assisted reproductive therapy	5 (6.9)	5 (5.3)	1.33 (0.37 - 4.78)	0.66
Miscarriage	6 (8.3)	7 (7.4)	1.12 (0.36 - 3.51)	0.83
Tubal pregnancy	1 (1.4)	0 (0)	-	1.00
Cesarean scar pregnancy	1 (1.4)	1 (1.1)	1.31 (0.08 - 21.30)	0.85

HNR, hysteroscopic niche resection; RR, risk ratio; Cl, confidence interval; PROM, premature rupture of fetal membrane.

Subgroup analysis - stratified by infertility before entry in the study

As shown in Table 3, in HNR group, 36 women had infertility before entry in the study, of whom 20 had a successful live birth (16 via natural conception, others via assisted reproductive therapy). In expectant management group, 19 women had infertility before entry in the study, of whom 5 had a successful live birth (2 via natural conception and 3 via assisted reproduction therapy). We observed significantly higher live birth rate ($p = 0.04$) and pregnancy rate ($p = 0.01$) in HNR group. The cumulative pregnancy rate was also higher in HNR group ($p = 0.02$). (Fig. 2 - B).

In women without infertility before entry in the study, no significant statistical differences were found in live birth rate. However, the pregnancy rate was higher in HNR group compare to that in expectant management group (n = 83.3% versus n = 64.0% respectively, risk ratio = 2.81, 95% CI 1.04–7.61, $p = 0.04$). The cumulative pregnancy rate between two groups was not different ($p = 0.10$). (Fig. 2 - C).

Cox proportional hazards analysis

After adjustment for confounding factors (age, number of CS, infertility before entry in the study, menstruation duration before treatment and management), cox proportional hazards analysis revealed that a HNR (AHR = 1.88, 95% CI 1.17–3.03, $p < 0.01$) was positively correlated to pregnancy, while age (AHR = 0.61, 95% CI 0.40–0.92, $p = 0.02$) and infertility before entry in the study (AHR = 0.51, 95% CI 0.32–0.82, $p < 0.01$) were negatively associated with pregnancy.(Table 4).

Discussion

Main findings

Live birth rate was not statistically significantly different in the two group. However HNR group achieved a higher pregnancy rate than expectant management group (72.2% versus 56.4%). We observed a miscarriage rate of 8.3% in HNR group versus 7.4% in expectant management group, both were lower than that in the general population (12%) [15].

Baseline characteristics showed that the incidence of infertility before entry in the study was significantly higher in HNR group, this was because infertile women were more likely to be offered niche resection and more likely to accept it. Therefore, subgroup analysis stratified by infertility before entry in the study was conducted to reduce bias. In women without infertility before entry in the study, the live birth rate did not differ, while the pregnancy rate was higher in women accepted HNR. However, in women with infertility before entry in the study, we found that live birth rate, pregnancy rate and cumulative pregnancy were significantly higher in HNR group than those in expectant management group.These results suggested that women with infertility might benefit more from HNR.

Comparison to other literature

A systemic review [16] contains 13 studies on HNR reported that this procedure could improve the live birth rate from 25% to 100% and the pregnancy rate from 44.4% to 100%. These results may be caused by small sample size and short follow-up.

However, most studies were single-arm studies without a control group and they did not differentiate between women with or without infertility. Correction for important confounders for pregnancy was also absent. The only RCT performed showed a significantly higher clinical pregnancy rate after HNR than that after expectant management in women diagnosed with infertility [13].

We performed subgroup analyses based on the presence or absence of infertility before entry in the study and explored confounders for pregnancy. Considering the influence of follow-up time on our result, a Cox proportional hazards analysis was performed. We found that HNR was positively correlated to pregnancy, while age and infertility before entry in the study were negatively associated with pregnancy. Several studies are consistent with our findings. Gubbini's prospective cohort study firstly reported the fertility outcomes in women who underwent HNR. All of 41 women with infertility caused by niche conceived again successfully after 2 years of follow-up [17]. Tsuji et al. reported that 71% conceived again in women who accepted HNR and suffered from infertility due to the niche [18].

We hypothesized that a HNR could benefit embryo implantation by removing hemorrhage in the niche cavity and reducing the interference on uterine mucus and sperm transport [19,20].

Meanwhile, little is known whether a HNR is safe in terms of the risk on cervical incompetence, CSP and placenta previa as HNR has no effect on restore the anatomy but may even enlarge the defect.

Both group observed adverse obstetric outcomes and adverse pregnancy outcomes. In China, preterm delivery rate and premature rupture of fetal membrane rate was round 4.9% – 10% [21] and 8% [22] separately. This was consistent with our study.

A *meta*-analysis identified [23] that the risk of placenta previa is higher after a previous CS. In our study, the rate of placenta previa was high in both group due to the small sample size and there was no significant statistical difference.

There existed one CSP in both groups. So far, the cause of CSP remains unclear, but the poor healing of the cesarean scar seems to favor the development of CSP [6,24]. Patient with postoperative CSP in HNR had two previous CSP history. No previous type of treatment for CSP has been proved to be associated with a recurrence of CSP, and whether the

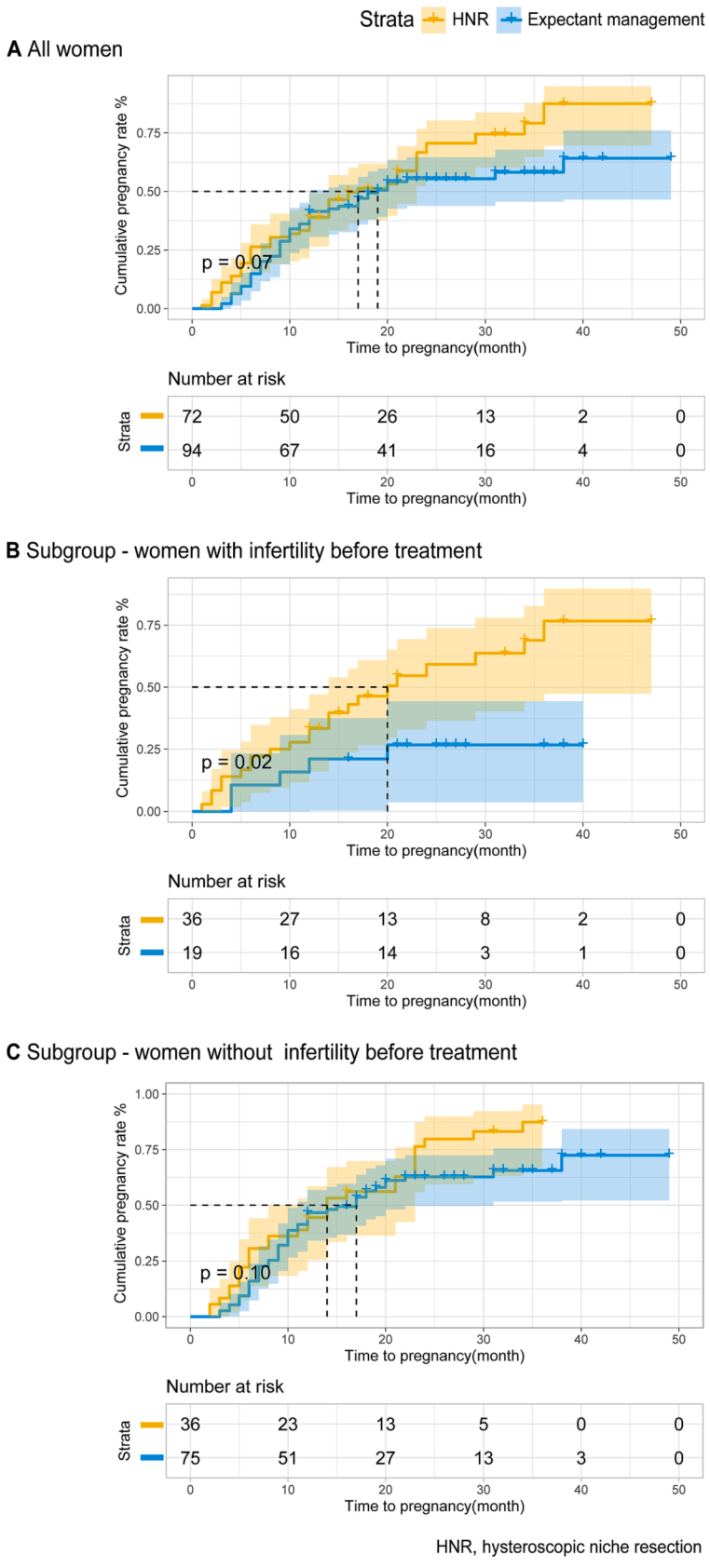

Fig. 2. Kaplan–Meier analysis for cumulative pregnancy rate A All women B Subgroup-women with infertility before entry in the study C Subgroup-women without infertility before entry in the study.

Table 3
Comparison of fertility outcomes stratified by infertility before entry in the study.

No. (%)	Women with infertility* before entry in the study				Women without infertility before entry in the study			
	HNR group (n = 36)	Expectant management group (n = 19)	RR [95% CI]	P value	HNR group (n = 36)	Expectant management group (n = 75)	RR [95% CI]	P value
Live birth rate	20 (55.6)	5 (26.3)	3.50 (1.04 - 11.79)	0.04	20 (55.6)	38 (50.7)	1.22 (0.55 - 2.70)	0.63
Mode of conception of live birth								
natural conception	16 (44.4)	2 (10.5)	6.80 (1.37 - 33.88)	0.01	19 (52.8)	36 (48.0)	1.21 (0.55 - 2.68)	0.64
conception after assisted reproductive therapy	4 (11.1)	3 (15.8)	0.67 (0.13 - 3.34)	0.62	1 (2.8)	2 (2.7)	1.04 (0.09 - 11.89)	0.97
Obstetric complication								
Preterm birth	2 (10.0)	0 (0)	-	1.00	1 (5.0)	2 (5.3)	0.95 (0.08 - 11.13)	0.97
Placenta previa	2 (10.0)	0 (0)	-	1.00	1 (5.0)	2 (5.3)	0.95 (0.08 - 11.13)	0.97
Postpartum hemorrhage	1 (5.0)	0 (0)	-	1.00	0 (0)	1 (2.6)	-	1.00
PROM	2 (5.0)	0 (0)	-	1.00	1 (5.0)	2 (5.3)	0.95 (0.08 - 11.13)	0.97
Pregnancy rate	22 (61.1)	5 (26.3)	4.40 (1.30 - 14.92)	0.01	30 (83.3)	48 (64.0)	2.81 (1.04 - 7.61)	0.04
Mode of conception of pregnancy								
natural conception	18 (50.0)	2 (10.5)	8.50 (1.71 - 42.28)	< 0.01	29 (80.5)	46 (61.3)	2.61 (1.01 - 6.73)	0.04
conception after assisted reproductive therapy	4 (11.1)	3 (15.8)	0.67 (0.13 - 3.34)	0.62	1 (2.8)	2 (2.7)	1.04 (0.09 - 11.89)	0.97
Miscarriage	0 (0)	0 (0)	-	NA	6 (16.7)	7 (9.3)	1.94 (0.60 - 6.27)	0.27
Tubal pregnancy	0 (0)	0 (0)	-	NA	1 (2.7)	0 (0)	-	1.00
Cesarean scar pregnancy	0 (0)	0 (0)	-	NA	1 (2.7)	1 (1.3)	2.11 (0.13 - 34.78)	0.60

HNR, hysteroscopic niche resection; RR, risk ratio; Cl, confidence interval; PROM, premature rupture of fetal membrane.
* Failure to conceive after one year of regular intercourse without contraception.

Table 4
Univariate and multivariate cox proportional hazards analysis of pregnancy

	HR [95% Cl]	P value	AHR [95% Cl]	P value
Age (year)				
< 35	reference	0.01	reference	0.02
≥ 35	0.60 [0.40 - 0.90]		0.61 [0.40 - 0.92]	
Number of CS				
1	reference	0.97	reference	0.73
≥ 2	0.99 [0.53 - 1.85]		0.90 [0.47 - 1.69]	
Infertility* before entry in the study				
Without	reference		reference	
With	0.60 [0.39 - 0.93]	0.02	0.51 [0.32 - 0.82]	< 0.01
Menstruation duration before treatment (day)				
≤ 8	reference		reference	
9-14	1.08 [0.72 - 1.63]	0.70	0.81 [0.50 - 1.32]	0.40
≥ 15	1.04 [0.54 - 2.02]	0.91	0.90 [0.45 - 1.81]	0.78
Management				
Expectant management	reference	0.08	reference	< 0.01
HNR	1.40 [0.96 - 2.06]		1.88 [1.17 - 3.03]	

HR, hazard ratio; AHR, adjusted hazard ratio; CI, confidence interval; CS, caesarean section; HNR, hysteroscopic niche resection
* Failure to conceive after one year of regular intercourse without contraception
HR was adjusted for age (years, < 35 versus ≥ 35), numbers of CS (1 versus ≥ 2), infertility before entry in the study (with versus without), menstruation duration before treatment (days, ≤ 8 versus 8-14 versus ≥ 15) and management (HNR versus expectant management).

niche should be repaired remains controversial [25]. Women who become pregnant again after CSP treatment should be encouraged to take ultrasound to detect the location of gestational sac as early as possible.

Laparoscopic niche resection (LNR) reconstruct and reinforce the lower uterine segment under direct vision, which is a good choice for women with infertility and with a symptomatic niche with a RMT < 2.5 mm [16].

Donnez O et al. followed up 18 women with infertility due to the niche, among which 44% had successful live birth after LNR [26]. Zhang et al. reported that in 26 women with infertility who underwent LNR, 84.6% conceived again [27].

LNR requires more than 1–2 years before preparation for pregnancy [26]. However, women could prepare for pregnancy as soon as the menstruation recovers after HNR. Therefore we believe that HNR can be a choice for women with sufficient RMT.

Strength and limitations

To our best knowledge, this study had the largest sample size to compare fertility outcomes after HNR and expectant management in women with a niche with RMT ≥ 2.5 mm. The strength of our study was that we had a long-term follow-up (up to 47 months). We corrected potential confounders for pregnancy. Another strength was that subgroup analyses were performed based on the presence or absence of infertility before entry in the study.

Drawbacks of our study were that the retrospective single-center cohort biased selection against a randomized study, our results still need to be validated in the future with larger clinical multicenter RCT.

Clinical implications

Our study only included women with a relatively small niche (RMT $\geq$ 2.5 mm).

As most cases of niche are asymptomatic, it is important to realize that not all niches need to be treated.

Meanwhile given the small sample size, our study was not powered to study differences in obstetric outcomes and adverse pregnancy outcomes. We can not draw any solid conclusion concerning the potential risk of a HNR on cervical incompetence or a higher risk on a CSP since it is expected that this procedure may enlarge the size of the niche.

Women need to be consulted concerning the possibility to undergo a HNR given a slightly higher live birth rate and pregnancy rate. Future RCT or at least prospective studies with long term follow-up should be recommended.

Conclusion

HNR may be superior to expectant management in women with infertility and with a symptomatic niche with a RMT $\geq$ 2.5 mm in terms of higher live birth rate and pregnancy rate, however this advantage is not clear in women without infertility. Future studies, preferably RCT with sufficient power are needed to study the effect of HNR on fertility outcomes.

Ethics approval and consent to participate

This study was approved by the Ethics Committee of the institutional ethics committee of IPMCH (GKLW 2017–126) and written informed consent was waived.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Author contributions

Jian Zhang and Ben W. Mol conceived and designed this study; Jian Zhang, JAF Hurine and Ben W. Mol contributed to the manuscript editing and language editing; Chuqing He was responsible for the data analysis and manuscript writing; Wei Xia, Li Yan, Yang Wang and Yuan Tian contributed to the data collection. The final version of manuscript has been approved by all authors.

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