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Comparison of Four Cervical Ripening and Labor Induction Strategies in Term Singleton Pregnancies with an Unfavorable Cervix: A Retrospective Cohort Study

Elverişsiz Serviksi Olan Term Tekil Gebeliklerde Dört Servikal Olgunlaştırma Ve Doğum İndüksiyonu Stratejisinin Karşılaştırılması: Retrospektif Kohort Çalışma

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ABSTRACT

Aim: To compare four cervical ripening and labor induction strategies in term singleton pregnancies with an unfavorable cervix with respect to vaginal delivery rate and induction-to-delivery interval.

Materials and Methods: This retrospective exploratory comparative cohort study was conducted at the Obstetrics Clinic of Ankara Bilkent City Hospital between November 2019 and September 2023. A total of 120 women at 37+0 to 42+0 weeks of gestation with singleton vertex pregnancies, cervical dilatation between 1 and 3 cm, and a Bishop score below 7 were included. Women were classified into four groups: manual cervical stretching with concomitant membrane sweeping alone, dinoprostone alone, immediate combination of the mechanical procedure and dinoprostone, and dinoprostone followed, when clinically indicated, by oxytocin augmentation as an escalation pathway. The primary outcome was vaginal delivery rate, and the main secondary outcome was the induction-to-vaginal-delivery interval among women who achieved vaginal birth.

Results: Vaginal delivery rate differed significantly among groups (53.3%, 76.7%, 80.0%, and 90.0%, respectively; p=0.009). In the whole cohort, the induction-to-delivery interval also differed significantly and was longest in Group 1 and shortest in Group 4 (31.2±4.5 h, 28.5±7.4 h, 26.3±7.2 h, and 25.0±4.8 h, respectively; p<0.001). Among women who delivered vaginally, the induction-to-vaginal-delivery interval remained significantly different (p=0.005). Cesarean delivery rates decreased progressively from Group 1 to Group 4. Apgar scores and postpartum pain scores were similar across groups.

Conclusion: In term singleton pregnancies with an unfavorable cervix, dinoprostone-containing strategies were associated with higher vaginal delivery rates than the mechanical-only approach. The highest vaginal delivery rate was observed in the group managed with oxytocin augmentation after dinoprostone; however, this group represented a clinically indicated escalation pathway rather than a pre-planned independent initial strategy, and this finding should be interpreted cautiously. The mechanical-only approach was associated with the longest induction-to-delivery interval.

Keywords: Labor, Induced; Cervical Ripening; Dinoprostone; Oxytocin; Term Birth

ÖZ

Amaç: Bu çalışmada, elverişsiz serviksi olan term tekil gebeliklerde kullanılan dört servikal olgunlaştırma ve doğum indüksiyonu stratejisinin vajinal doğum oranı ve doğum indüksiyonu-doğum aralığı açısından karşılaştırılması amaçlandı.

Gereç ve Yöntemler: Bu retrospektif keşifsel karşılaştırmalı kohort çalışması, Kasım 2019-Eylül 2023 tarihleri arasında Ankara Bilkent Şehir Hastanesi Obstetri Kliniğinde yürütüldü. Çalışmaya 37+0 ile 42+0 gebelik haftaları arasında, baş geliş, servikal dilatasyonu 1 cm ile 3 cm arasında ve Bishop skoru 7'nin altında olan 120 gebe dahil edildi. Olgular belge kayıtlarına göre dört gruba ayrıldı: yalnızca manuel servikal germe ve eş zamanlı membran sıyırma, yalnızca dinoproston, mekanik işlem sonrası hemen dinoproston ve klinik gereksinim halinde dinoproston sonrası oksitosin augmentasyonu şeklindeki bir eskalasyon yolu. Primer sonlanım vajinal doğum oranıydı. Ana sekonder sonlanım, vajinal doğum yapan kadınlarda doğum indüksiyonu-vajinal doğum aralığıydı.

Bulgular: Vajinal doğum oranı gruplar arasında anlamlı olarak farklıydı (%53,3; %76,7; %80,0; %90,0; p=0,009). Doğum indüksiyonu ile doğum arasındaki süre tüm kohortta anlamlı farklılık gösterdi ve en uzun süre Grup 1'de, en kısa süre Grup 4'te saptandı (31,2±4,5 saat; 28,5±7,4 saat; 26,3±7,2 saat; 25,0±4,8 saat; p<0,001). Vajinal doğum yapan kadınlarda indüksiyon-vajinal doğum aralığı da anlamlı farklıydı (p=0,005). Sezaryen oranı Grup 1'den Grup 4'e doğru azaldı. Apgar skorları ve postpartum ağrı skorları açısından gruplar arasında anlamlı fark yoktu.

Sonuç: Elverişsiz serviksi olan term tekil gebeliklerde dinoproston içeren stratejiler, yalnızca mekanik yaklaşıma göre daha yüksek vajinal doğum oranları ile ilişkiliydi. En yüksek vajinal doğum oranı, dinoproston sonrası oksitosin augmentasyonu uygulanan grupta gözlendi; ancak bu grup, başlangıçtan planlanmış bağımsız bir stratejiden ziyade klinik gereksinim halinde uygulanan bir eskalasyon yolunu temsil etmekteydi ve bu bulgu temkinli yorumlanmalıdır. Yalnızca mekanik yaklaşım ise en uzun doğum indüksiyonu-doğum aralığı ile ilişkiliydi.

Anahtar Kelimeler: Doğum indüksiyonu; servikal olgunlaşma; dinoproston; oksitosin; term doğum

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INTRODUCTION

Induction of labor is a key obstetric intervention when the maternal or fetal benefits of delivery outweigh the risks of continuing pregnancy (1). In women with an unfavorable cervix, the method and sequence of cervical ripening may influence both vaginal delivery rates and the induction-to-delivery interval (2). This issue is particularly relevant at term, where several accepted options exist but direct comparative evidence remains limited (1,2).

Membrane sweeping is a simple bedside procedure that may promote labor onset and reduce the need for formal induction, although systematic reviews suggest its effects on delivery mode are less consistent than its effects on spontaneous labor onset and pregnancy duration (3,4). Its role as a formal induction method has been studied less than its outpatient or serial use to prevent prolonged gestation. In the randomized trial by El-Torkey and Grant, sweeping increased spontaneous labor in prolonged pregnancy, but the primary endpoint was spontaneous labor rather than vaginal delivery (5). Similarly, trials by de Miranda et al. and Yildirim et al. mainly assessed serial or term sweeping to reduce post-term pregnancy and encourage spontaneous labor before inpatient induction was required (6,7).

Dinoprostone remains a widely used pharmacologic agent for cervical ripening at term. Meta-analyses and prospective studies support the effectiveness of controlled-release dinoprostone vaginal inserts, although vaginal delivery rates and time intervals vary according to cervical status, parity, and local protocols (8-10). Evidence on combining or sequencing dinoprostone with sweeping-based procedures is limited and inconsistent. One randomized study found no significant benefit of adjunctive sweeping on delivery timing or mode, whereas another reported higher spontaneous vaginal delivery rates and a shorter induction-to-delivery interval when sweeping was performed at the start of formal induction (11,12).

We therefore compared four routine cervical ripening and induction strategies in term singleton pregnancies with an unfavorable cervix: manual cervical stretching with concomitant membrane sweeping alone, dinoprostone alone, their immediate combination, and dinoprostone followed by oxytocin augmentation when clinically indicated. The primary outcome was vaginal delivery rate, and the main secondary outcome was the induction-to-vaginal-delivery interval among women who achieved vaginal birth.

MATERIALS AND METHODS

This retrospective exploratory comparative study was conducted at the Obstetrics Clinic of Ankara Bilkent City Hospital and included women managed between November 2019 and September 2023. Ethical approval was obtained from the Ankara Bilkent City Hospital 1st Medical Research Scientific and Ethical Evaluation Board (TABED 1/178/2024, 08 May 2024). Individual informed consent was waived because de-identified archived records were reviewed retrospectively. The study complied with the Declaration of Helsinki.

Eligible women were aged ≥21 years and had singleton, vertex pregnancies at 37+0 to 42+0 weeks, cervical dilatation ≥1 cm and <3 cm at admission, and a Bishop score <7. Gestational age was based on the last menstrual period and revised by first-trimester ultrasonography when discordant. Women with previous cesarean delivery, prior uterine surgery, grand multiparity, non-vertex presentation, ruptured membranes at admission, or any contraindication to vaginal birth were excluded.

Archived obstetric records and labor charts were reviewed retrospectively. Because of practical file-review constraints and the approved study plan, the sample was assembled as an exploratory comparative cohort rather than as a consecutive all-eligible series. Screening within each analytic group continued until 30 eligible women were identified, yielding 120 women in total. Thus, the study sample represented a non-consecutive, pragmatically assembled cohort rather than a randomly selected sample from a complete eligible population. This sampling approach should be considered when interpreting between-group comparability.

The induction approach in routine practice was chosen by the treating team and was not randomized. Women were classified retrospectively into four analytic groups according to the documented intervention sequence: Group 1, manual cervical stretching with concomitant membrane sweeping alone; Group 2, controlled-release dinoprostone vaginal insert (Propess®, 10 mg dinoprostone [prostaglandin E2]) alone, without subsequent oxytocin augmentation; Group 3, manual cervical stretching with concomitant membrane sweeping followed immediately by dinoprostone during the same examination; and Group 4, dinoprostone followed by oxytocin augmentation after dinoprostone removal when adequate spontaneous uterine contractions did not develop. Group 4 was therefore a retrospectively defined escalation pathway rather than a pre-planned initial strategy. Records with other intervention sequences were excluded, including manual cervical stretching with concomitant membrane sweeping plus dinoprostone followed by oxytocin augmentation.

In Groups 1 and 3, the mechanical procedure was performed during vaginal examination as part of routine institutional practice. The examining finger was introduced into the cervical canal and gentle but firm digital pressure was applied to stretch the cervix.

When the internal os could be traversed, the inferior pole of the fetal membranes was circumferentially separated from the lower uterine segment using a circular sweeping motion. Because of the retrospective design, formal operator-level standardization could not be assessed; however, cases were classified only when the documented procedure was consistent with this institutional approach.

In Groups 2, 3, and 4, dinoprostone was administered as a controlled-release vaginal insert. In Group 3, the insert was placed immediately after the mechanical procedure. In Group 4, oxytocin augmentation was considered only after dinoprostone removal and a waiting interval of at least 30 minutes. Oxytocin was started in women who had not entered spontaneous labor and had not developed an adequate uterine contraction pattern, defined as 3–4 contractions in 10 minutes. Dinoprostone and oxytocin were not used concurrently.

Collected variables were maternal age, body mass index, gravida, parity, previous vaginal births, gestational age at admission, indication for induction, Bishop score at admission, duration of dinoprostone exposure, duration of oxytocin exposure, mode of delivery, time from induction initiation to delivery, cesarean indication, 1- and 5-minute Apgar scores, and postpartum visual analog scale pain score.

The primary outcome was vaginal delivery rate. The main secondary outcome was the interval from induction initiation to vaginal delivery among women who achieved vaginal birth. Additional secondary outcomes were the overall induction-to-delivery interval in the full cohort, cesarean delivery rate, cesarean indications, Apgar scores, postpartum pain score, and duration of dinoprostone and oxytocin exposure.

Induction initiation was defined as the time of the first cervical ripening or induction intervention. In Group 3 it was the time of the mechanical procedure, and in Group 4 it was the time of dinoprostone insertion rather than oxytocin initiation.

Continuous variables were summarized as mean ± standard deviation and categorical variables as number and percentage. Categorical variables were compared using Pearson chi-square or Fisher's exact test, and baseline continuous variables using one-way analysis of variance. Because variance homogeneity was not present for delivery interval outcomes, Welch analysis of variance was used for induction-to-delivery comparisons. Kruskal-Wallis testing was used for Apgar and postpartum pain scores. When overall comparisons were significant, exploratory pairwise comparisons were performed with Welch t tests and Holm correction. All tests were two-sided, and $p<0.05$ was considered statistically significant. Analyses were performed with Python 3.13 using pandas, SciPy, and statsmodels.

RESULTS

A total of 120 women met the study criteria and were analyzed, with 30 women in each group. No included record had missing data for the primary outcome or the induction-to-delivery interval. Baseline maternal and obstetric characteristics were comparable across groups, with no significant differences in age, body mass index, parity-related variables, gestational age, or admission Bishop score (Table 1). Indications for induction were also similar, and post-term pregnancy was the most common indication in all groups (Table 3).

The primary outcome, vaginal delivery rate, differed significantly among the four strategies (p=0.009). Vaginal delivery occurred in 53.3% of women in Group 1, 76.7% in Group 2, 80.0% in Group 3, and 90.0% in Group 4 (Table 2). Exploratory pairwise analysis showed that the main difference was between Groups 1 and 4 and remained significant after Holm correction.

Table 1. Baseline maternal and obstetric characteristics

Characteristic	Group 1	Group 2	Group 3	Group 4	p
Age, years	30.6 ± 6.4	30.7 ± 6.5	30.4 ± 6.7	30.3 ± 6.9	0.996
Body mass index, kg/m²	25.5 ± 4.2	24.7 ± 4.1	24.8 ± 4.1	24.3 ± 4.0	0.727
Gravida	1.2 ± 0.6	1.3 ± 0.6	1.4 ± 0.9	1.3 ± 0.7	0.793
Previous vaginal births, n	0.2 ± 0.5	0.3 ± 0.6	0.4 ± 0.9	0.3 ± 0.7	0.689
Gestational age at admission, weeks	40.1 ± 1.5	39.7 ± 1.3	39.5 ± 1.3	39.6 ± 1.2	0.325
Admission Bishop score	3.7 ± 1.1	3.3 ± 1.2	3.3 ± 1.1	3.1 ± 1.1	0.256
Nulliparous, n (%)	25 (83.3)	24 (80.0)	22 (73.3)	23 (76.7)	0.806
Previous vaginal birth, n (%)	5 (16.7)	6 (20.0)	8 (26.7)	7 (23.3)	0.806

Notes: Data are presented as mean ± standard deviation or n (%). Group comparisons were performed with one-way analysis of variance for continuous variables and the chi-square test for categorical variables.

In the full cohort, the induction-to-delivery interval differed significantly across groups (Welch p<0.001). The mean interval was longest in Group 1 (31.2 ± 4.5 h), intermediate in Groups 2 and 3 (28.5 ± 7.4 h and 26.3 ± 7.2 h), and shortest in Group 4 (25.0 ± 4.8 h) (Table 2). Exploratory post hoc testing suggested that this difference was mainly attributable to the longer interval in Group 1 than in Groups 3 and 4.

Among women who achieved vaginal birth, the induction-to-vaginal-delivery interval also differed significantly (Welch p=0.005): 31.1 ± 4.6 h in Group 1, 27.7 ± 6.6 h in Group 2, 26.8 ± 7.5 h in Group 3, and 25.3 ± 5.0 h in Group 4 (Table 2). After Holm correction, the clearest pairwise difference remained between Groups 1 and 4.

Neonatal condition at birth, Apgar scores, and postpartum pain scores were similar across groups (p=0.732, p=0.870, and p=0.240, respectively). Among dinoprostone-treated groups, mean dinoprostone exposure duration did not differ significantly (p=0.105), whereas mean oxytocin exposure duration in Group 4 was 10.3 ± 4.2 h (Table 2).

Cesarean delivery rates decreased progressively from 46.7% in Group 1 to 10.0% in Group 4 (Table 2). The most frequent cesarean indication in all groups was cephalopelvic disproportion or arrest of progress, especially in Group 1, while fetal distress accounted for a minority of cesarean deliveries (Table 4).

Table 2. Induction characteristics and study outcomes

Outcome	Group 1	Group 2	Group 3	Group 4	p
Vaginal delivery, n (%)	16 (53.3)	23 (76.7)	24 (80.0)	27 (90.0)	0.009
Cesarean delivery, n (%)	14 (46.7)	7 (23.3)	6 (20.0)	3 (10.0)	0.009
Induction-to-delivery interval, h (entire cohort)	31.2 ± 4.5	28.5 ± 7.4	26.3 ± 7.2	25.0 ± 4.8	<0.001
Induction-to-vaginal-delivery interval, h*	31.1 ± 4.6	27.7 ± 6.6	26.8 ± 7.5	25.3 ± 5.0	0.005
1-minute Apgar score	7.7 ± 1.4	7.6 ± 1.4	7.6 ± 1.4	7.4 ± 1.3	0.732
5-minute Apgar score	9.3 ± 0.8	9.3 ± 0.8	9.4 ± 0.8	9.2 ± 1.0	0.870
Postpartum VAS score	6.1 ± 2.3	4.9 ± 1.3	5.0 ± 1.3	5.2 ± 1.9	0.240
Dinoprostone exposure, h†	–	14.3 ± 3.7	12.4 ± 3.7	12.7 ± 2.5	0.105
Oxytocin exposure, h‡	–	–	–	10.3 ± 4.2	–

Notes: Data are presented as mean ± standard deviation or n (%). Delivery interval outcomes were compared using Welch analysis of variance. Apgar and postpartum VAS scores were compared using the Kruskal-Wallis test. *Calculated among women who achieved vaginal delivery. †Compared among Groups 2–4 only. ‡Available only in Group 4. VAS, visual analog scale.

Table 3. Indications for labor induction, n (%)

Indication	Group 1	Group 2	Group 3	Group 4
Post-term pregnancy	19 (63.3)	19 (63.3)	17 (56.7)	19 (63.3)
IUGR	3 (10.0)	2 (6.7)	5 (16.7)	3 (10.0)
Oligohydramnios	3 (10.0)	4 (13.3)	4 (13.3)	3 (10.0)
Hypertension	2 (6.7)	2 (6.7)	2 (6.7)	2 (6.7)
Polyhydramnios	2 (6.7)	2 (6.7)	1 (3.3)	3 (10.0)
Gestational diabetes	1 (3.3)	1 (3.3)	1 (3.3)	0 (0.0)

Notes: Values are n (%). Percentages are column percentages within each group. The overall distribution of induction indications did not differ significantly between groups (chi-square p=0.998). IUGR, intrauterine growth restriction.

Table 4. Indications for cesarean delivery, n (%)

Cesarean indication	Group 1	Group 2	Group 3	Group 4
Cephalopelvic disproportion / arrest of progress	13 (92.9)	5 (71.4)	4 (66.7)	1 (33.3)
Fetal distress	1 (7.1)	2 (28.6)	2 (33.3)	2 (66.7)
Total cesarean deliveries, n	14	7	6	3

Notes: Values are n (%), with percentages calculated among cesarean deliveries within each group.

DISCUSSION

In this retrospective cohort of term singleton pregnancies with an unfavorable cervix, vaginal delivery rates differed significantly across the four induction strategies, being lowest in the mechanical-only group and highest in the dinoprostone-to-oxytocin escalation pathway. Both the overall induction-to-delivery interval and the induction-to-vaginal-delivery interval were longest in the mechanical-only group, whereas neonatal Apgar scores and postpartum pain scores were similar across groups. The main observed between-group differences concerned delivery success and timing rather than short-term neonatal condition.

These findings should be interpreted in the context of the membrane sweeping literature. Systematic reviews suggest that membrane sweeping may reduce formal induction and shorten pregnancy duration, but they have not shown a consistent benefit for delivery mode outcomes (3,4). Most sweeping studies were also not designed around inpatient induction success. The trial by El-Torkey and Grant evaluated sweeping as a direct induction maneuver in prolonged pregnancy, but its primary endpoint was spontaneous labor rather than vaginal delivery (5). In contrast, the trials by de Miranda et al. and Yildirim et al. mainly assessed serial sweeping in low-risk term pregnancies and reported reductions in post-term pregnancy or prolonged gestation rather than direct comparisons of inpatient induction success (6,7). In our cohort, the mechanical-only group comprised women already admitted for formal induction with an unfavorable cervix; vaginal delivery occurred in 53.3% and the mean time to vaginal birth was 31.1 h. Differences in setting and endpoint likely explain why our findings should not be viewed as a direct contradiction of earlier sweeping trials.

The dinoprostone-containing groups showed vaginal delivery rates of 76.7% to 90.0%, broadly consistent with previous reports using controlled-release dinoprostone inserts (8-10). Our dinoprostone-alone group achieved a somewhat higher vaginal delivery rate than some previous studies, which may reflect more favorable baseline cervical status because our inclusion criteria allowed Bishop scores below 7.

The comparison between Group 2 and Group 3 is also informative. Adding the sweeping-based mechanical procedure before dinoprostone was associated with a slightly higher vaginal delivery rate and a slightly shorter time to vaginal birth than dinoprostone alone, although the difference was modest. This differs from the randomized trial by Bhatia et al., in which adjunctive sweeping with dinoprostone did not significantly improve labor duration or delivery mode (11). Our findings are more directionally aligned with Tan et al., who reported that membrane sweeping at the start of formal induction increased spontaneous vaginal delivery and shortened the induction-to-delivery interval (12). Together, these data suggest that any benefit from adding a sweeping-based maneuver may depend on technique, timing, background ripening protocol, and study population.

Group 4 should be interpreted as a clinically indicated escalation pathway rather than a pre-planned independent initial strategy, because oxytocin was added only after dinoprostone when spontaneous labor and adequate contractions had not developed. Within this escalation pathway, the highest vaginal delivery rate was observed. These findings may be compatible with a potential benefit of stepwise escalation when initial pharmacologic ripening alone is insufficient; however, this interpretation should remain cautious because the comparison was retrospective, non-randomized, and potentially affected by confounding by indication. The absence of clearly worse short-term neonatal outcomes in this group is nevertheless reassuring, but should not be interpreted as proof of superiority. Our sequential, rather than concurrent, use of dinoprostone and oxytocin also accords with prescribing guidance.

This study has several limitations. Its retrospective single-center design limited control of confounding and precluded causal inference. In addition, the sample was a non-consecutive, pragmatically assembled exploratory cohort with 30 women per group rather than a consecutive all-eligible series; therefore, selection bias cannot be excluded. Screening stopped once 30 eligible women had been identified in each group, no random selection from a complete eligible population was performed, and the total number of potentially eligible women was unavailable. Treatment allocation reflected routine clinical practice rather than randomization. Group 4 was a retrospectively defined escalation pathway among women initially managed with dinoprostone, which may have reduced between-group comparability and introduced confounding by indication. The sweeping-based mechanical procedure was operator dependent, and the retrospective dataset did not allow formal assessment of inter-operator variability or procedural standardization, which may limit reproducibility. We also lacked analyzable data on tachysystole, epidural analgesia, serial cervical change, and the clinical reasoning underlying treatment choice and escalation. Postpartum pain scores may likewise have been influenced by delivery mode and analgesic use, variables that could not be adequately adjusted for.

The study also has strengths. It compared four explicitly defined real-world intervention pathways within the same institution and time frame, applied consistent inclusion and exclusion criteria, and

evaluated a clinically meaningful outcome often underemphasized in induction studies: time to vaginal birth among women who achieved vaginal delivery. The explicit definition of induction start time also reduced ambiguity in the combined and escalation groups. These features make the findings useful for hypothesis generation and for informing the design of future prospective studies.

CONCLUSION

In term singleton pregnancies with an unfavorable cervix, dinoprostone-containing strategies were associated with higher vaginal delivery rates than the mechanical-only approach in this retrospective cohort. The highest vaginal delivery rate was observed in the group managed with oxytocin augmentation after dinoprostone; however, this group represented a clinically indicated escalation pathway rather than a pre-planned independent initial strategy. Accordingly, this finding should be interpreted as hypothesis-generating rather than as evidence of superiority. The mechanical-only approach was associated with the longest induction-to-delivery interval. Prospective comparative studies are needed.

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