

Transvaginal sonographic single-sweep sonographic measurements of cervix score to predict successful labor induction: Results from a double-blind prospective study

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Abstract

Objective: The primary objective of the study was to compare an integrated transvaginal sonographic score, incorporating parameters – cervical length, funneling, and posterior cervical angle (PCA) – with the Modified Bishop score (MBS) in predicting successful labor induction. The secondary objectives included a comparison of the acceptability of both methods as determined by the study participants' perception of pain. **Methods:** All consenting patients underwent baseline evaluation, including maternal age, gestational age, body mass index, parity, estimated fetal weight, and indication for induction. Transvaginal sonography (TVS) with a 5–7 MHz probe measured cervical length, funneling, and PCA to calculate a TVS score named single-sweep sonographic measurements of cervix (SSMC Score), followed by MBS assessment. Labor induction was performed using intracervical Prostaglandin E2 or E1 analog as per standard protocol. Successful induction was defined as vaginal delivery within 24 h; failed induction included cesarean delivery or inability to achieve active labor. **Results:** A total of 100 participants were eligible for the study. Postdated pregnancy was the most common indication for labor induction in the present study. Higher MBS (≥ 6), cervical length < 28 mm, presence of funneling, and PCA $> 120^\circ$ were significantly associated with successful induction. Receiver operating characteristic analysis identified cervical length (area under the curve [AUC] ~ 0.80) as the most accurate predictor, slightly outperforming MBS (AUC ~ 0.77), whereas the integrated TVS score showed comparable efficacy (AUC ~ 0.77) vis-à-vis MBS with lesser perception of pain on the Visual Analog Scale. **Conclusion:** TVS-based SSMC Score is equally efficacious, an objective predictor of successful labor induction compared to age-old subjective MBS, with a better acceptability among participants.

Keywords: Labor induction, Modified Bishop's score, Single-sweep sonographic measurements of cervix score, Transvaginal sonography

1. Introduction

Induction of labor represents one of the most frequently performed obstetric interventions in contemporary clinical practice. Globally, it is estimated that up to 20% of pregnancies involve labor induction through various pharmacological or mechanical methods.^[1] Induction of labor is defined as the deliberate and controlled initiation of uterine contractions through pharmacological or mechanical means, before the spontaneous onset of labor, at any point following the achievement of fetal viability. The primary objective is to promote progressive cervical effacement and dilatation, ultimately facilitating a safe and timely vaginal delivery while minimizing maternal and fetal risks.^[2]

The likelihood of achieving a successful vaginal delivery following induction largely depends on the pre-induction cervical status, traditionally evaluated using the Bishop score. The Modified Bishop Scoring (MBS) system evaluates cervical favorability by assessing five key parameters: cervical position, consistency, length (effacement), dilation, and the station of the fetal presenting part. Despite its widespread use, the determination of the MBS through digital vaginal examination remains inherently subjective, yet quantifiable with significant inter- and intra-observer variability and a sensitivity of around 23–64%.^[3,4] This limitation has prompted ongoing research into the development and validation of more objective, reproducible, and quantifiable methods for assessing cervical readiness, aiming to improve the predictive accuracy for successful induction of labor.^[4,5] Trans vaginal sonography (TVS) has emerged as a valuable tool in obstetric practice, particularly in the context of labor induction. Its increasing application is attributed to its ability to provide a precise and objective assessment of cervical characteristics, overcoming many limitations of traditional digital examination.^[5-7]

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The traditional TVS scoring system encompasses various sonographic parameters such as cervical length, length and width of funnel, position of cervix, and distance between presenting part to external OS.^[8] In addition to cervical length and funneling, another anatomical parameter, i.e., posterior cervical angle (PCA), has gained attention as a potential predictor of successful labor induction. It is defined as the angle formed between the posterior uterine wall and the cervical canal at the level of the internal OS, quantitatively assessed by TVS. A wider PCA is significantly associated with increased likelihood of successful vaginal delivery following induction of labor, whereas narrower angles have been linked to prolonged labor and higher rates of cesarean delivery.^[7]

Objective sonographic parameters such as cervical length, cervical funneling, and PCA offer more reliable and reproducible predictors of induction outcomes. The present study proposes a simple scoring system, namely, single-sweep sonographic measurements of cervix (SSMC) score, which incorporates these three transvaginal ultrasound markers, minimizing complexity while enhancing objectivity and predictive accuracy.

The present study aimed to evaluate transvaginal parameters, namely, cervical length, funneling, and PCA individually, for the prediction of successful labor induction, along with formulation and assessment of the SSMC score incorporating all three parameters for this purpose. The secondary goal was to compare the SSMC score with the most practiced MBS in terms of predictability and tolerability of both methods. Our hypothesis was that the SSMC score could be a better score in comparison with MBS for the prediction of successful labor induction with enhanced acceptability.

2. Material and methods

2.1. Study design, setting, and participants

It was a prospective double-blinded cross-sectional comparative study which included 100 women who were admitted for induction of labor in the Antenatal ward of Gandhi Memorial Hospital associated with Shyam Shah Medical College, Rewa, India, from January 2024 to December 2024 (1 year). Women who gave written informed consent were included in this study. The study was approved by the Institutional Ethics Committee, Shyam Shah Medical College, Rewa (No-31098, December 2023).

Inclusion criteria included: (1) A singleton pregnancy, (2) vertex presentation, (3) live pregnancy, (4) 37–42 weeks of gestation, (5) intact amniotic membranes

Exclusion criteria included: (1) Scarred uterus, e.g., previous cesarean section, myomectomy, etc., (2) pre-term or post-term pregnancy, (3) presence of medical disorders, (4) multiple pregnancy, (5) allergy to prostaglandins, (6) anomalous fetus, (7) fetal weight more than 4 kg.

2.2. Procedures

Gestational age was first confirmed by first-trimester sonography in combination with menstrual history, and an MBS was calculated by a single researcher every time. Another researcher was assigned to measure cervical parameters through TVS, and the SSMC score was calculated. Both researchers were blinded to each other's findings. Induction was done by the researcher who calculated MBS. Outcome (vaginal delivery or cesarean section) was directly disclosed to the third researcher, who then performed data analysis after collecting MBS and SSMC scores of study participants from both researchers. After examination, the perception of women about the procedure (vaginal and TVS) was noted using a Visual Analog Scale (VAS), where “0” means no pain and “10” means very painful.

2.3. TVS measurement of cervical parameters

A transvaginal sonography using a 5–7 MHz probe was performed on the study participants after emptying the bladder. The TVS probe was inserted gently toward the anterior fornix. A single-sweep sagittal image of the cervix (occupying 50–70% of the screen) was obtained after identifying the landmarks, namely, external OS, cervical canal, internal OS [Figure 1]. Through this image, cervical length, funneling length (if present), and PCA were calculated [Figure 2].

2.4. Calculation of SSMC score

Each cervical parameter was given a score of 0 or 1, depending on the result, resulting in a minimum SSMC score of 0 and a maximum SSMC score of 3 [Table 1]. A score of 2 or more was taken as favorable.

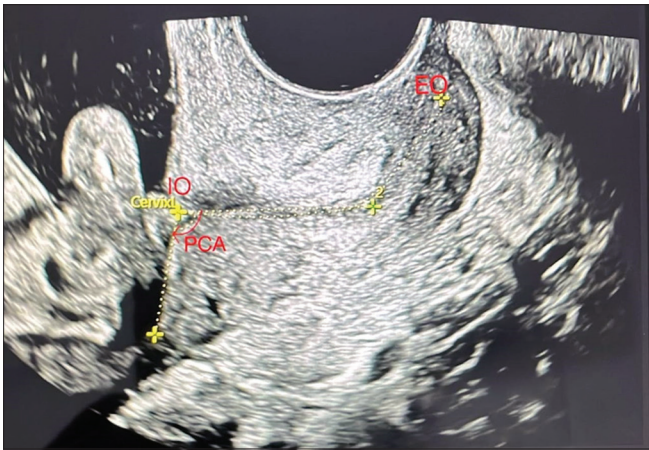


Figure 1: Single-sweep measurements of the cervix without funneling. IO: Internal OS, EO: External OS, PCA: Posterior cervical angle

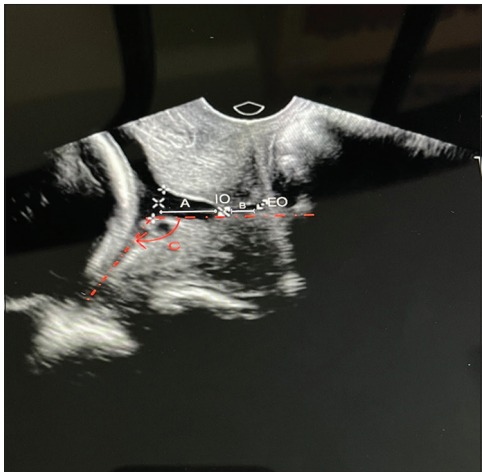


Figure 2: Single-sweep measurements of the cervix with funneling. IO: Internal OS, EO: External OS, A: Funnel, B: Cervical length, C: Posterior cervical angle

Table 1: Formulation of single-sweep sonographic measurements of cervix score

S. No.	Parameters	Score	
		0	1
1	Cervical length	≥ 28	< 28
2	Posterior cervical angle	$< 120^\circ$	$\geq 120^\circ$
3	Funneling	No	Yes

A total score of ≥ 2 was taken as favorable

2.5. Induction of labor

Labor induction was done by researcher one as per standard protocols using either prostaglandin E2 gel or misoprostol tablet, depending upon MBS score. Failed induction and failure of progress of labor were defined as per standard definitions.

2.6. Data analysis

It was done by the third researcher after obtaining data from researchers one and two using SPSS 24.0 Version. The collected data were subjected to appropriate statistical analyses, including descriptive and inferential tests, to evaluate associations and predictive value. Categorical variables were analyzed using Chi-square or Fisher’s exact test as appropriate. Receiver operating characteristic (ROC) curve analysis was performed to assess the predictive performance of individual parameters, including Bishop’s score, cervical length, Funneling, PCA, and integrated SSMC score for successful labor induction. The area under the curve (AUC) was calculated for each parameter. $P < 0.001$ was considered statistically significant.

3. Results

A total of 100 women were enrolled in the study after considering the inclusion and exclusion criteria. Out of 100 women, 67 women delivered vaginally, and 33 women underwent cesarean section. The most common indication for induction of labor in the present study was postdated pregnancy [Table 2]. A statistically significant association was found between MBS ≥ 6 and the likelihood of vaginal delivery, with a $P < 0.001$. On analysis of the association of TVS parameters individually, it was found that cervical length showed a highly significant association with mode of delivery ($P < 0.001$), followed by posterior cervical length and funneling, which were also found to be statistically significant. ROC analysis showed an AUC of 0.77 for MBS and 0.80, 0.74, and 0.68 for cervical length, PCA, and funneling, respectively [Figure 3]. The integrated SSMC score showed an AUC of 0.77, which is comparable with MBS [Figure 4]. Comparison of sensitivity, specificity, and likelihood ratio of MBS, TVS parameters, and SSMC score is depicted in Table 3. The VAS analysis concluded better tolerability with TVS scoring than manual MBS. Perception of pain was much lower with TVS (mean score 2, IQR 3) than MBS (mean score 5, IQR 4), with a $P < 0.001$.

Table 2: Distribution according to indications for labor induction

Indication for labor induction	Vaginal delivery <i>n</i> (%)	Cesarean section <i>n</i> (%)	Total <i>n</i> (%)
Post-term pregnancy	34 (50.74)	11 (33.33)	45 (45.0)
PROM	04 (5.97)	01 (3.03)	05 (5.0)
Oligohydramnios	02 (2.98)	05 (15.15)	07 (7.0)
HDP	16 (23.88)	05 (15.15)	21 (21.0)
GDM	05 (7.466)	6 (18.18)	11 (11.0)
IUGR	04 (5.97)	0.0	04 (4.0)
Others	02 (2.98)	05 (15.15)	07 (7.0)

n: Number of patients in the sample, PROM: Premature rupture of membranes, HDP: Hypertensive disorders of pregnancy, GDM: Gestational diabetes mellitus, IUGR: Intrauterine growth restriction, Others: Reduced fetal movements, intrahepatic cholestasis of pregnancy, %: Percentage of participants

Table 3: Diagnostic accuracy of MBS, ultrasound parameters, and SSMC score

Characteristic	Sensitivity	Specificity	LR+	LR–	AUC
Modified Bishop score (≥ 6)	0.86	0.66	2.58	0.21	0.77
Cervical length (>28 mm)	0.88	0.71	3.07	0.17	0.80
Posterior cervical angle (>120)	0.84	0.60	2.12	0.27	0.74
Funneling length (yes or no)	0.70	0.66	2.10	0.45	0.68
SSMC score (≥ 2)	0.78	0.72	2.79	0.31	0.77

LR+: Likelihood ratio positive, LR–: Likelihood ratio negative, AUC: Area under the curve, SSMC: Single-sweep sonographic measurements of cervix

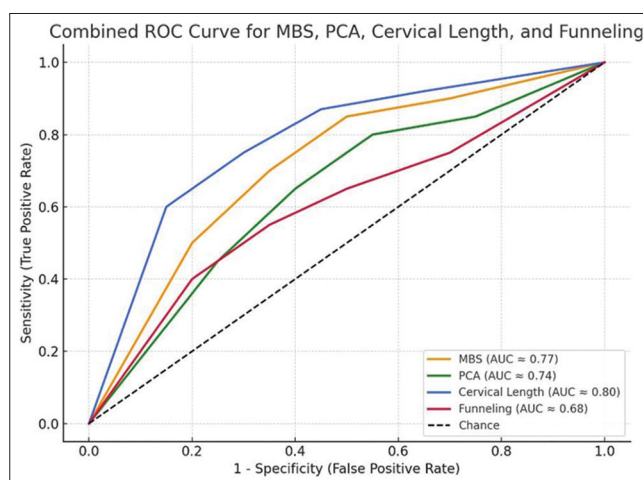


Figure 3: Receiver operating characteristic curves for Modified Bishop Score and cervical parameters

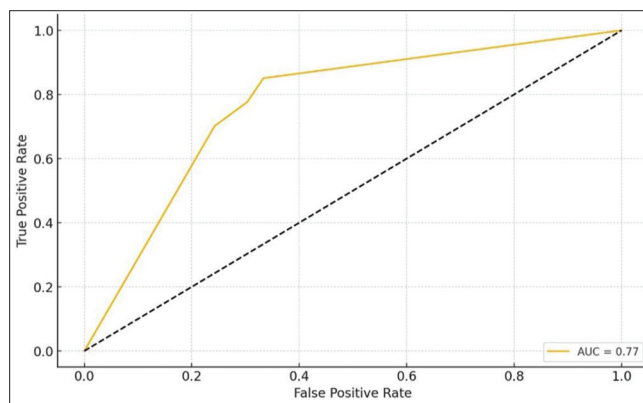


Figure 4: Receiver operating characteristic curve for single-sweep sonographic measurements of cervix score derived through transvaginal sonography

4. Discussion and Conclusion

In contemporary obstetric practice, labor induction is undertaken in approximately 20% of all deliveries and continues to rise.^[1] However, inappropriate case selection can result in failed inductions and an increased incidence of intrapartum cesarean deliveries, thereby contributing to heightened maternal and neonatal morbidity.^[2] This underscores the critical need for accurate preinduction assessment and patient counseling regarding the likelihood of a successful outcome. Consequently, the development and integration of reliable, objective tools to predict induction success are essential for optimizing clinical decision-making and improving perinatal outcomes. Our study emphasizes evaluating the role of a very simple single-sweep TVS method to measure cervical parameters in one go, formulating the SSMC score incorporating cervical length, funneling, and PCA, and comparing it with the already existing MBS.

The findings of the present study underscore the significant predictive value of transvaginal sonographic (TVS) assessment of cervical length in determining the likelihood of successful vaginal delivery following induction. A cervical length of <28 mm was strongly associated with vaginal delivery, with 85.1% of women in this category delivering vaginally, compared to only 14.9% in those with cervical lengths ≥ 28 mm. This association was statistically highly significant, highlighting cervical length as a reliable and objective marker of cervical favorability.

These findings are consistent with recent literature. Sreenivas *et al.*^[9] conducted a prospective observational study involving 300 pregnant women undergoing induction of labor. They found that a cervical length ≤ 2.5 cm, measured through TVS, was significantly associated with successful vaginal delivery within 24 h. The study concluded that TVS cervical length assessment was a better predictor of successful induction compared to the Bishop score. Furthermore, research conducted by Alanwar *et al.*,^[10] which highlighted the predictive value of cervical length, as assessed by transvaginal sonography, in determining labor progression following induction, demonstrated a statistically significant inverse correlation between cervical length and the duration of labor, indicating that shorter cervical lengths were associated with more rapid labor onset and progression. Similarly, a study by Wang *et al.*^[11] demonstrated that shorter cervical lengths (≤ 3.415 cm) were associated with a higher chance of successful labor induction.

In the present study, the presence of funneling was significantly associated with the mode of delivery ($P < 0.001$), with a notably higher rate of vaginal deliveries observed among women exhibiting funneling (70.14%) compared to those without it (29.85%). Similarly, a study by Rane *et al.*^[12] demonstrated that cervical funneling, when evaluated using transvaginal sonography, was significantly associated with spontaneous onset of labor and favorable delivery outcomes. Studies by Li *et al.*^[13] and Bano *et al.*^[14] also suggested the same association. In addition, Agrawal *et al.*^[15] found that combining cervical length and funneling provided a better prediction of induction success than cervical length alone.

In the present study, the results revealed a statistically significant association between PCA and the likelihood of vaginal delivery. Among participants with a PCA $>120^\circ$, 83.87% delivered vaginally, whereas only 39.47% with a PCA $\leq 120^\circ$ achieved vaginal delivery. A study by Al-Adwy *et al.*,^[16] suggested that PCA of more than 99.5° yielded the best accuracy in predicting successful induction of labor. Kamel *et al.*^[17] also investigated this relationship and found that a PCA $>125^\circ$ was significantly associated with successful vaginal delivery following labor induction. Kim *et al.*^[7] reported that the area under the ROC curve for predicting vaginal delivery using the PCA was 0.667, with a cutoff value of 96.5° , indicating a significant association with successful vaginal delivery. These findings closely align with the results of our study, which demonstrated a comparable AUC of 0.68 for PCA. Bayoumy *et al.*^[18] proposed a PCA threshold of $>100^\circ$ as a predictor of successful labor induction, demonstrating

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a high sensitivity of 87.8%. This further reinforces the clinical utility of PCA as a dynamic and adaptable ultrasonographic parameter for forecasting induction success.

In the present study, the transvaginal SSMC score demonstrated a good predictive performance for vaginal delivery, with an AUC of 0.77. This finding suggests that the TVS score can reliably discriminate between successful and unsuccessful inductions, with better tolerability. The present study developed a simplified TVS score based on three cervical parameters: cervical length, PCA, and funneling. This model yielded an AUC of 0.77 on ROC analysis, indicating fair predictive capability with more objectivity. The incorporation of cervical length, PCA, and funneling into a single predictive score likely enhances the sensitivity and specificity of the model. The moderate-to-high predictive accuracy indicated by the ROC curve supports the clinical utility of TVS as a non-invasive, objective alternative to traditional methods of pre-induction cervical assessment, such as the MBS. In the literature, very few studies are available that have integrated multiple TVS parameters to develop a single score. Bajpai *et al.* (2015)^[8] developed the Manipal Cervical Scoring System, incorporating cervical length, funneling, cervical position, and the distance of the presenting part from the external OS. This composite sonographic assessment yielded an AUC of 0.90 on ROC analysis, reflecting an excellent predictive accuracy for successful labor induction. In the study by Agrawal *et al.*,^[15] the transvaginal sonographic (TVS) cervical score incorporated five parameters – cervical length, funneling at the internal OS, cervical position, and the distance of the presenting part from the external OS – achieving an AUC of 0.91, thereby demonstrating excellent predictive accuracy for successful labor induction.

Given its ease of use, minimal time requirement, and objective nature, the transvaginal sonographic SSMC Score serves as a valuable alternative, particularly since the Bishop's score is limited by interobserver variability, limited reproducibility, and lesser acceptability.

4.1. Future areas of research

Building upon the present study, the development of a weighted TVS Score, in which cervical parameters are assigned differential weightage based on their individual predictive strength, may further improve diagnostic precision. Rather than allocating equal importance to all components, this approach allows for the prioritization of more robust predictors. In the present study, cervical length emerged as the most sensitive and specific standalone parameter, suggesting it should carry greater influence within the scoring algorithm, followed by PCA and funneling.

4.2. Strengths and limitations

The key strength of the present study lies in the inclusion of the PCA, an underutilized parameter in the clinical context, making this study uniquely positioned to contribute original insights. Furthermore, the study proposes a simplified transvaginal ultrasound-based SSMC Score incorporating three objective parameters – cervical length, PCA, and funneling – which facilitates a direct, structured comparison with the MBS.

Despite offering valuable insights, this study is not without limitations that may impact the robustness and external validity of its conclusions. First of all, while the Bishop score represents a composite assessment of five distinct cervical parameters, its comparison with only three ultrasound-derived variables may not provide an entirely equitable analytical framework. Recent advancements in sonographic evaluation have explored other parameters – such as transperineal head–perineum distance, cervical gland area, and angle of head progression – as promising predictors of induction success and timing of delivery. Moreover, the relatively small sample size ($n = 100$) in the present study may limit the statistical power and generalizability of the findings, and underscore the need for larger, multicentric trials to validate these results.

5. Author's Contribution

1. Dr. Beenu Kushwah – Research design, planning, conduct, and manuscript writing
2. Dr. Sweta Goyal – Data collection, Analysis, and Manuscript writing

6. Conflict of Interest

None.

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