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SONOGRAPHIC ASSESSMENT OF CERVICAL LENGTH VS BISHOP SCORE IN PREDICTING OUTCOME OF LABOUR INDUCTION

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ABSTRACT

Background: The ability to predict successful labor induction is essential in managing nulliparous women. This study compares the effectiveness of cervical length (CXL) measurement via transvaginal ultrasound and the Bishop score (BS) in predicting the success of labor induction.

Methods: A cohort of 422 nulliparous women undergoing labor induction was studied. The predictive value of CXL and BS was assessed by evaluating the correlation between these parameters and the success of labor induction within 24 hours.

Results: Both CXL and BS were found to be significant predictors of successful induction. The sensitivity and specificity of CXL were 50.3% and 63.2%, respectively, with a cutoff value of ≤3.05 cm. The Bishop score showed comparable predictive value, with a cutoff of ≥3. The success rate of induction was 74.9%, and the failure rate was 25.1%. Our findings are consistent with several previous studies but highlight some differences in the optimal cut-off values and diagnostic characteristics between studies.

Conclusion: Cervical length, as measured by transvaginal ultrasound, can be considered a viable alternative to the Bishop score for predicting labor induction success. Both methods, when used together, offer a more comprehensive approach to predicting induction outcomes. Further research is needed to refine cut-off values and improve prediction accuracy.

Keywords: Cervical length, Bishop score, labor induction, nulliparous women, transvaginal ultrasound, successful induction, predictive value, pre-induction assessment, obstetrics, cervical ripening.

INTRODUCTION

Every pregnancy should result in the birth of a healthy baby and a healthy mother. However, it is not always possible to wait for the spontaneous onset of labor. Induction of labor is necessary in certain cases for either maternal or fetal conditions [1]. Induction of labor refers to the deliberate

initiation of labor and delivery beyond 28 weeks of pregnancy, a period of viability, using various methods. Induced labor may lead to an instrumental delivery or cesarean section [2]. The decision to induce labor depends on assessing the obstetric balance by weighing the risks of continuing the pregnancy against the risks associated with its interruption. Before induction, cervical ripening is assessed using the Bishop score, introduced by Bishop in 1964 [3]. The Bishop score, which evaluates the pre-induction favorability of the cervix, has traditionally been used to predict whether induced labor will result in a successful vaginal delivery [4]. A low Bishop score has been associated with failure of induction, prolonged labor, and a higher rate of cesarean deliveries. However, this assessment is subjective, and several studies have demonstrated poor predictive value for induction outcomes in women with a low Bishop score [5]. Transvaginal cervical length measurement, which was initially used to detect cervical changes in women at risk of preterm delivery, has also been explored as a predictor of the success of labor induction. Theoretically, transvaginal ultrasonographic measurement of the cervix may offer a more accurate and objective assessment than digital examination [6]. The supravaginal portion of the cervix, which comprises about 50% of its total length, is difficult to assess digitally in a closed cervix. Additionally, effacement, which begins at the internal os, is hard to predict in a closed cervix. Sonographic measurement of cervical length is a quantitative and reproducible method that provides an objective assessment of the cervix with minimal discomfort for the patient [7]. Transvaginal sonographic measurement of cervical length is the only biophysical marker that has been evaluated as an alternative to the Bishop score [8]. This study aimed to determine whether transvaginal ultrasound, with its ability to objectively measure cervical length, could predict the outcome of induction better than clinical assessment using the Bishop score. If proven effective, transvaginal ultrasonographic measurement of cervical length could serve as an adjunct tool to the traditional Bishop score, providing additional valuable information in the field of successful induction of labor.

MATERIAL AND METHODS

Study Design: Prospective Comparative Study

Sample Size and Source of Data: A sample size of 500 primigravida women with a gestational age ranging from 37 to 41 weeks, who are admitted for labor induction under Obstetrics and Gynecology at Govt. Raja Mirasdar Hospital, Thanjavur Medical College, Thanjavur, is planned.

Duration of Study: January 2018 to June 2019 (18 months)

Inclusion Criteria:

1. Primigravida of GA 37-41 weeks
2. Age 20-35 years
3. Singleton pregnancy
4. Live foetus
5. Cephalic presentation
6. Reassuring NST pattern before induction
7. No contraindications for vaginal delivery

Exclusion Criteria

1. Multiple gestations
2. Bleeding per vaginum
3. Anamolous foetus
3. Dead foetus

A total of 500 patients who are willing to participate in this study will be included. Baseline characteristics such as age, height, weight, gestational age at induction, and indication for induction will be recorded. The indication for induction will be explained to the patients, and informed consent for induction will be obtained. For cervical length assessment, the patient will be placed in the dorsal position with flexed hips and knees. Transvaginal ultrasonographic measurement of cervical length will be performed using a standard longitudinal view of the cervix with the bladder

empty. A SONORAY TVS probe with a 7.5 MHz frequency will be used to measure cervical length. The probe will be positioned 3 cm away from the posterior fornix, and cervical length will be defined as the distance between the internal os and the external os. Three measurements will be taken, and the shortest value will be recorded. Following sonographic assessment, the Bishop score will be determined through a digital examination performed by another obstetrician who will be blinded to the cervical length measurements.

Labor induction was carried out according to the standard hospital protocol. If the cervix is favorable, oxytocin induction was initiated. If the cervix is unfavorable, either a Foley catheter or Prostaglandin E2 (PGE2) gel was used for cervical ripening. Patients undergoing Foley catheter insertion will be reassessed after 12 hours. The catheter will then be removed, and the cervix will be re-evaluated. If the cervix is favorable, oxytocin induction will be initiated. If unfavorable, PGE2 gel will be applied, with reassessment after 6 hours. A maximum of three PGE2 gel applications was allowed, and subsequent doses was withheld if the patient enters active labor. If the cervix remains unfavorable, amniotomy and oxytocin induction was performed before considering the case as failed induction.

Fetal heart rate tracing was conducted before each induction. Labor progress was monitored using a partograph. Out of 500 women, 78 underwent cesarean section (CS) during the latent phase due to causes such as fetal distress, meconium-stained amniotic fluid (MSAF), cephalopelvic disproportion (CPD), cord presentation, and placental abruption, and these cases were excluded from the study. The remaining 422 women were followed up. The active phase of labor was defined as the presence of 3–4 contractions every 10 minutes, each lasting 45–60 seconds, with cervical dilatation of ≥4 cm.

Definitions of Labor Induction Outcomes:

Successful induction: Active labor (cervical dilatation ≥4 cm) achieved within 24 hours from the last dose of induction.

Failed induction: Inability to reach the active phase of labor (cervical dilatation ≥4 cm) within 24 hours from the last dose of induction.

Primary Outcome Measures:

1. Number of vaginal deliveries, including assisted deliveries.
2. Number of CS performed for causes other than failed induction, where cervical dilatation was ≥4 cm.
3. Number of CS performed for failed induction.

Secondary Outcome Measures:

1. Induction-to-active phase interval.
2. Induction-to-delivery interval.
3. Maternal outcomes.
4. Perinatal outcomes.

Cases in which CS was performed for causes such as fetal distress, MSAF, deflexed head, failure to descend/progress after entering the active phase of labor (i.e., cervical dilatation ≥4 cm) was considered as successful inductions in this study.

RESULTS

Data were entered in the excel spreadsheet and variables were coded accordingly. The statistical analyses were performed using Graph pad Prism version 5 software. Data were presented as frequency with proportion n (%) for categorical data. Unpaired‘t’ test was used to compare the means between the group. Fisher’s exact test was used to compare the frequency between the groups. Pearson’s correlation test was used to correlate the variables and the strength of association was estimated using r value. ROC curve was constructed for cervical length and bishop score to estimate the cut-off point for successful induction. $p<0.05$ was considered statistically significant.

Age Distribution of the Study Population

The frequency distribution of age categories among the study population. The total number of participants included in the analysis was 422. The majority of the participants (51.2%) belonged to the 21–25 years age group (n = 216), followed by 26–30 years (n = 129, 30.6%). A smaller proportion of participants were below 21 years (n = 58, 13.7%) and 31–35 years (n = 19, 4.5%). These findings suggest that the most common age group undergoing labor induction in this study was 21–25 years, with fewer participants in the older age category (Fig. 1). Data are expressed as n (%), where N = 422.

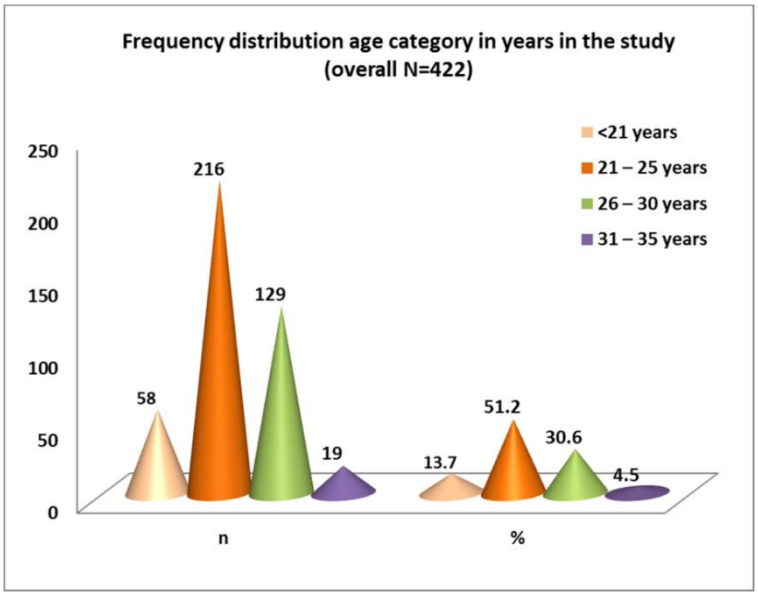


Figure1: Frequency distribution of age category in the study population.

Description of Various Parameters Measured in the Study Population

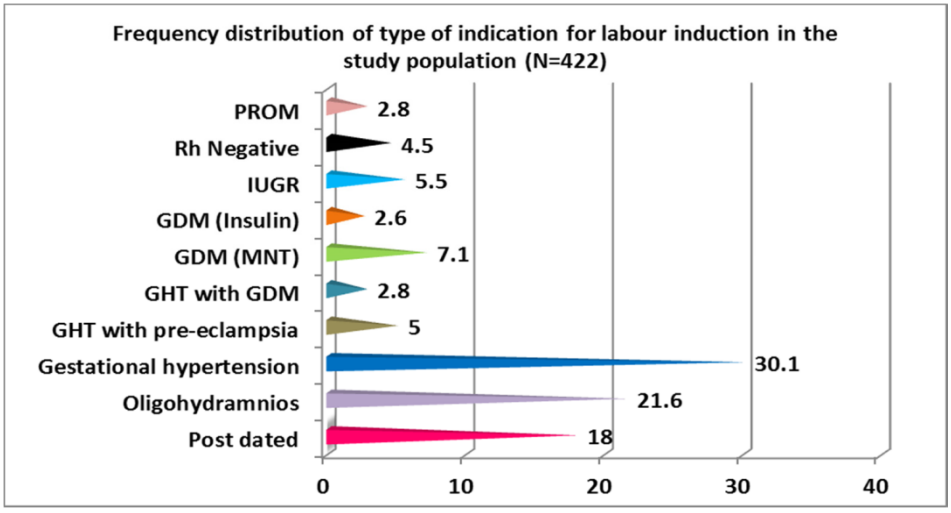
The various parameters assessed in the study population. The mean age of the participants was 24.47 ± 3.28 years**,** with a range of 20 to 35 years**.** The mean height was 153.2 ± 5.64 cm (range: 137–169 cm**),** while the mean weight was 63.1 ± 11.8 kg**,** ranging from 40 to 105 kg**.** The mean BMI was recorded as 26.86 ± 4.76**,** with values ranging from 17.9 to 43.15. The mean gestational age at induction was 39.31 ± 1.16 weeks (range: 37–41 weeks**).** The mean cervical length measured using transvaginal sonography was 3.11 ± 0.46 cm**,** with a minimum of 2 cm and a maximum of 4.2 cm. The mean Bishop score at the time of induction was 2.63 ± 1.22, with values ranging from 0 to 5. Regarding labor progression, the mean induction-to-active phase interval was 17.9 ± 10.1 hours**,** with a range of 2 to 45 hours**.** The mean induction-to-delivery time was 23.4 ± 11.1 hours**,** with values ranging from 3.58 to 49.32 hours (Table 1)**.** These findings provide key insights into the baseline characteristics and labor progression patterns in the study population.

Table: 1 Description of Various Parameters Measured in the Study Population

S.No	Parameter	Mean	SD	Minimum	Maximum
1	Ageinyears	24.47	3.28	20	35
2	Heightincm	153.2	5.64	137	169
3	WeightinKg	63.1	11.8	40	105
4	BMI	26.86	4.76	17.9	43.15
5	Gestationalageinweeks	39.31	1.16	37	41
6	Cervicallengthincm	3.11	0.46	2	4.2
7	Bishopscore	2.63	1.22	0	5
8	Induction to active phase (hr)	17.9	10.1	2	45
9	Induction todelivery time (hr)	23.4	11.1	3.58	49.32

Frequency Distribution of Indications for Labor Induction in the Study Population

The frequency distribution of various indications for labor induction among the study population **(**N = 422). The most common indication for induction was gestational hypertension (GHT), observed in 127 women (30.1%), followed by oligohydramnios in 91 women (21.6%) and postdated pregnancy in 76 women (18%). Other indications included gestational hypertension with pre-eclampsia (n = 21, 5%), gestational hypertension with gestational diabetes mellitus (GDM) (n = 12, 2.8%), and isolated GDM managed with medical nutrition therapy (MNT) **(**n = 30, 7.1%) or insulin **(**n = 11, 2.6%). Additionally, intrauterine growth restriction (IUGR) was noted in 23 women (5.5%), while Rh-negative status was observed in 19 women (4.5%)**.** Premature rupture of membranes (PROM) accounted for 12 cases (2.8%) (Fig.2).



Figue:2 Frequency distribution of type of indication for labour induction in the study population

Frequency Distribution of Bishop Scores in the Study Population

The distribution of Bishop scores among the study population (N = 422). The majority of participants had a Bishop score of 3 (n = 151, 35.8%), followed by those with a score of 4 (n = 100, 23.7%) and score of 2 (n = 92, 21.8%). Lower Bishop scores were observed in 36 women (8.5%) with a score of 0 and 35 women (8.3%) with a score of 1**.** Only 8 women (1.9%) had a Bishop score of 5 at the time of induction. These findings indicate that most women in the study had low Bishop scores (≤3), suggesting an unfavorable cervix at the time of induction. Data are expressed as n (%)**,** with a total sample size of N = 422 (Fig.3).

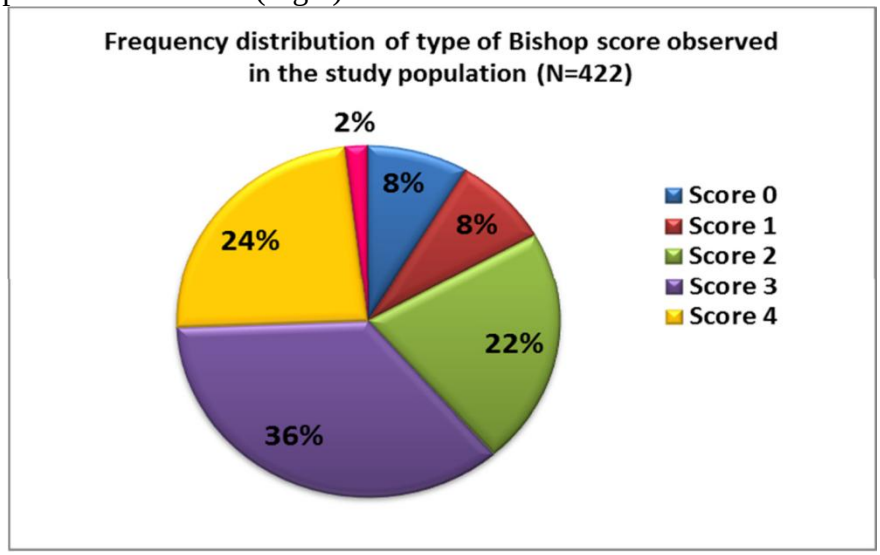


Figure: 3 Frequency Distribution of Bishop Scores in the Study Population

Frequency Distribution of Cervical Length Categories in the Study Population

The distribution of cervical length categories among the study population (N = 422). The most common cervical length observed was in the >2.5–3 cm range (n = 144, 34.1%), followed closely by the >3–3.5 cm category (n = 143, 33.9%). A cervical length of >3.5–4 cm was seen in 76 women (18%), while 47 women (11.1%) had a cervical length in the >2–2.5 cm range. A small proportion of participants had either ≤2 cm **(**n = 3, 0.7%**)** or >4 cm **(**n = 9, 2.1%**)**. These findings indicate that the majority of women had a cervical length between 2.5 and 3.5 cm at the time of induction**,** which is generally associated with an unfavorable cervix**.** Data are expressed as n (%)**,** with a total sample size of N = 422 (Fig.4)**.**

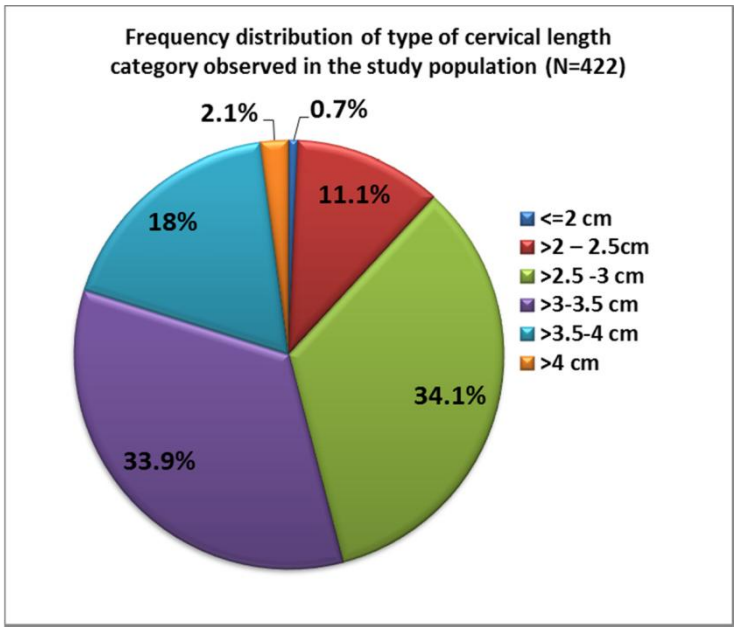


Figure: 4 Frequency Distribution of Cervical Length Categories in the Study Population

Frequency Distribution of Mode of Delivery in the Study Population

The distribution of different modes of delivery among the study population (N = 422). The majority of women had a spontaneous vaginal delivery (natural labor) **(**n = 240, 56.9%), while 51 women (12.1%) underwent assisted delivery using interventions such as forceps or vacuum extraction. A significant proportion of women (n = 106, 25.1%) required lower-segment cesarean section (LSCS) due to failed induction**,** indicating that they did not achieve active labor despite induction attempts. Additionally, 25 women (5.9%) underwent LSCS for other indications**,** even though they had reached more than 4 cm cervical dilatation (Table.2).

Table: 2 Frequency Distribution of Mode of Delivery in the Study Population

S.No	Type of mode of delivery	n	%
1	Labour natural	240	56.9
2	Assisted delivery	51	12.1
3	LSCS for failed induction	106	25.1
4	LSCS for other cause with more than 4 cm cervicaldilatation	25	5.9

Frequency Distribution of Induction Outcomes in the Study Population

Table 3 presents the distribution of labor induction outcomes among the study population (N = 422**).** Successful induction was observed in 316 women (74.9%)**,** which includes those who delivered vaginally and those who reached ≥4 cm cervical dilatation but required cesarean section for other indications. In contrast, 106 women (25.1%) experienced failed induction**,** meaning they did not achieve active labor (cervical dilatation ≥4 cm) within 24 hours of the last induction dose.

Table: 3 Frequency Distribution of Induction Outcomes in the Study Population

S.No	Outcome of induction	n	%
1	Failedinduction	106	25.1
2	Successfulinduction (delivered + not delivered with 4 cm cervicaldilatation)	316	74.9

Comparison of Age Categories Between Patients With Failed and Successful Induction

Table 4 presents the comparison of age categories between women who had failed induction (n = 106, 25.1%) and those who had successful induction (n = 316, 74.9%)**.** The highest proportion of failed inductions was observed in the 21–25 years age group (n = 52, 49.1%**),** followed by the 26–30 years age group (n = 37, 34.9%). Among those who had a successful induction**,** the 21–25 years category also had the highest proportion (n = 164, 51.9%), followed by the 26–30 years group (n = 92, 29.1%). A lower proportion of failed inductions was observed in women aged <21 years **(**n = 10, 9.4%**)** and 31–35 years **(**n = 7, 6.6%**),** compared to successful induction cases in the same age groups **(**15.2% and 3.8%, respectively**).** The Chi-square test value was 4.298 with 3 degrees of freedom (df)**,** and the p-value was 0.231, indicating no statistically significant association (NS) between age and induction outcome**.**

Table: 4 Comparison of Age Categories Between Patients With Failed and Successful Induction

S. No	Age in years	Failed induction (n=106)		Successful induction (n=316)		Chi square value	df	pvalue
		n	%	n	%			
1	<21years	10	9.4	48	15.2	4.298	3	0.231 (NS)
2	21–25years	52	49.1	164	51.9			
3	26–30years	37	34.9	92	29.1			
4	31–35years	7	6.6	12	3.8			

Comparison of Age Categories Between Patients With Bishop Score

The comparison of age categories between women with Bishop Score <3 (n = 163, 38.6%) and those with Bishop score ≥3 (n = 259, 61.4%)**.** The highest proportion of women with Bishop score <3 belonged to the 21–25 years age group (n = 89, 54.6%**),** followed by the 26–30 years group (n = 46, 28.2%). Similarly, among those with Bishop Score ≥3, the highest proportion was also observed in the 21–25 years group (n = 127, 49%**),** followed by the 26–30 years category (n = 83, 32%). A lower proportion of women in the <21 years and 31–35 years age groups had Bishop Score <3 **(**11.7% and 5.5%, respectively**)** and Bishop score ≥3 **(**15.1% and 3.9%, respectively**)**. The Chi-square test value was 2.539 with 3 degrees of freedom (df)**,** and the p-value was 0.468**,** indicating no statistically significant association (NS) between age and Bishop score category.

Comparison of Age Categories between Patients with Different Cervical Length Status

The comparison of age categories between women with cervical length ≤3.05 cm (n = 198, 46.9%) and those with cervical length >3.05 cm (n = 224, 53.1%)**.** In both cervical length categories, the highest proportions were observed in the 21–25 years age group, with 49.5% of women with cervical length ≤3.05 cm (n = 98) and 52.7% of women with cervical length >3.05 cm **(**n = 118**).** The 26–30 years age group made up 30.3% of the group with cervical length ≤3.05 cm (n = 60) and 30.8% of the group with cervical length >3.05 cm (n = 69). A smaller proportion of women in both groups were in the <21 years and 31–35 years categories. For cervical length ≤3.05 cm**,** 14.6% were under 21 years **(**n = 29**),** and 5.6% were in the 31–35 years category (n = 11). In the cervical length >3.05 cm group, 12.9% were under 21 years (n = 29), and 3.6% were in the 31–35 years category (n

= 8). The Chi-square value was 1.357 with 3 degrees of freedom (df), and the p-value was 0.716**,** indicating no statistically significant association (NS) between age and cervical length**.**

Comparison of Cervical Length and Bishop Score Based on the Outcome of Induction

The comparison of cervical length and Bishop score between women with failed induction (n = 106, 25.1%) and successful induction (n = 316, 74.9%)**.** The mean cervical length in women with failed induction was 3.28 cm (SD = 0.48)**,** which was significantly higher than the mean cervical length in women with successful induction **(**3.05 cm, SD = 0.44). The t-value for the comparison was 4.512 with 420 degrees of freedom (df)**,** and the p-value was 0.000008, indicating a statistically significant difference ($p < 0.05$) between the two groups. Similarly, the mean Bishop score for women with failed induction was 2.3 (SD = 1.25)**,** while the mean Bishop score for women with successful induction was 2.74 (SD = 1.19)**.** The t-value was 3.27 with 420 df**,** and the p-value was 0.00115**,** indicating a statistically significant difference ($p < 0.05$) (Fig.5)**.**

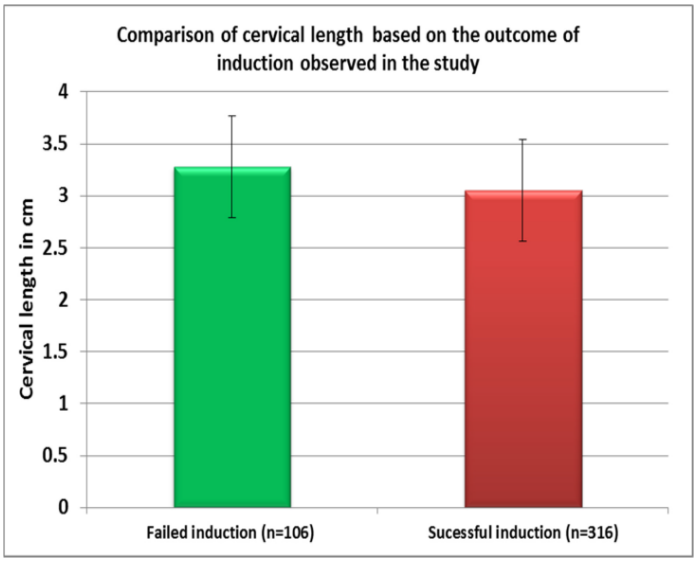


Figure: 5 Comparison of Cervical Length and Bishop Score Based on the Outcome of Induction

Description of Time Taken from Induction to Delivery in the Study Population

The distribution of the time taken from induction to delivery among the study population (N = 422). A little over half of the participants (225 women, 53.3%) had their delivery within 24 hours of induction, while the remaining 197 women (46.7%) took ≥24 hours to deliver.

Description of Time Taken from Induction to Active Phase in the Study Population

The distribution of the time taken from induction to active phase among the study population (N = 317). A total of 104 women (32.8%) achieved active phase within 12 hours of induction, while the majority, 213 women (67.2%)**,** took ≥12 hours to reach the active phase of labor.

Comparison of Bishop Score and Cervical Length with Respect to Induction to Delivery Time Interval

Table 5 presents the comparison of cervical length and Bishop score between two groups: those who delivered in <24 hours (n = 225) and those who took ≥24 hours (n = 197) from induction to delivery. The mean cervical length in women who delivered in <24 hours was 3.01 cm (SD = 0.45)**,** which was significantly lower than the mean cervical length in women who delivered in ≥24 hours **(**3.21 cm, SD = 0.44**).** The t-value for this comparison was 4.66 with 420 degrees of freedom (df)**,** and the p-value was 0.00004**,** indicating a statistically significant difference ($p < 0.05$). Similarly, the mean Bishop score for women who delivered in <24 hours was 2.94 (SD = 1.11)**,** which was significantly higher than the mean Bishop score for women who delivered in ≥24 hours **(**2.28, SD =

1.24**)**. The t-value was 5.71 with 420 df**,** and the p-value was <0.00001**,** indicating a statistically significant difference ($p < 0.05$).

Table: 5 Comparison of Bishop Score and Cervical Length with Respect to Induction to Delivery Time Interval

S. No	Parameter	Induction to delivery interval				t value	df	pvalue
		<24hours (n=225)		≥24hours (n=197)				
		Mean	SD	Mean	SD			
1	Cervical lengthincm	3.01	0.45	3.21	0.44	4.66	420	0.00004*
2	BishopScore	2.94	1.11	2.28	1.24	5.71	420	<0.00001*

Receiver Operating Characteristic (ROC) Curve Construction for the Selection of Cut-off Value for Cervical Length for Successful Induction of Labour

The ROC curve analysis for determining the optimal cut-off point of cervical length to predict successful induction of labor (Fig.6). The sensitivity and specificity values at various cervical length cut-off points were calculated to assess the performance of cervical length as a predictor for successful induction.

- At a cut-off of <2.04 cm, the sensitivity was 94.94% (95% CI: 0.1962% to 2.749%), and the specificity was 100.0% (95% CI: 96.58% to 100.0%).
- At a cut-off of <2.205 cm, sensitivity decreased to 2.532% (95% CI: 1.099% to 4.927%), while specificity remained high at 99.06% (95% CI: 94.86% to 99.98%).
- As the cervical length cut-off increased, the sensitivity gradually improved, reaching 94.62% (95% CI: 91.53% to 96.84%) at a cut-off of <3.810 cm.
- Specificity, however, decreased with increasing cut-off points. At the highest cut-off point of <4.015 cm, sensitivity reached 100% (95% CI: 98.84% to 100%), but specificity dropped to 8.49% (95% CI: 3.956% to 15.51%).

The area under the curve (AUC) was 0.632 with a standard error of 0.03, and the p-value was <0.0001, indicating that the model is statistically significant when compared with the line of identity.

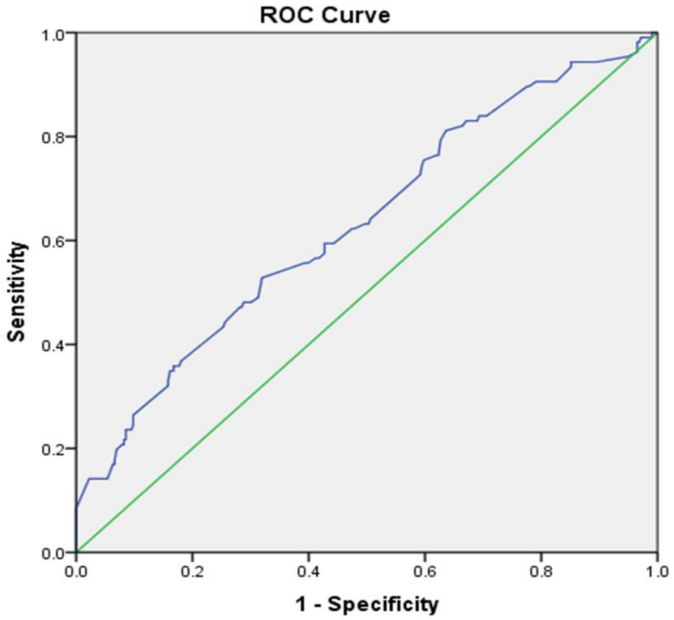


Figure: 6 Receiver Operating Characteristic (ROC) Curve Construction for the Selection of Cut-off Value for Cervical Length for Successful Induction of Labour

Comparison of Induction Success Based on Bishop Score and Gestational Age

The data offer a comparison of primary outcome indicators based on the Bishop score (BS) vs gestational age and induction success. In the 37-39 week group, women with a Bishop score less than 3 had a 34.9% failed induction rate, compared to 11.07% successful induction. When the Bishop score was ≥3, 21.2% of inductions were successful and 22.6% failed. In the >39-40 weeks group, those with BS ≥3 had a reduced failed induction rate (13.2%) compared to BS <3 (7.5%), and the successful induction rate was considerably greater (24.6%) compared to BS <3 (8.9%). Similarly, in the >40 weeks group, when the Bishop score rose to ≥3, the success rate climbed (21.2%) and the failure rate decreased to 8.5% (Table 6).

Table: 6 Comparison of primary outcome measures based on bishop score with respect to the gestational age in weeks.

S. No	Gestational age		Successful induction (n=316)		Failed induction (n=106)	
			n	%	n	%
1	37 – 39 weeks (n=163)	BS <3	35	11.07	37	34.9
		BS ≥3	67	21.2	24	22.6
2	>39 – 40 weeks (n=128)	BS <3	28	8.9	8	7.5
		BS ≥3	78	24.6	14	13.2
3	>40 weeks (n=131)	BS <3	41	12.9	14	13.2
		BS ≥3	67	21.2	9	8.5

Data are expressed as n with %.

Similarly, in the >40 weeks group, when the Bishop score rose to ≥3, the success rate climbed (21.2%) and the failure rate decreased to 8.5%. Overall, the data suggests that as the gestational age grows and the Bishop score gets more favorable (≥3), the risk of unsuccessful induction lowers and the success rate increases. Similarly, in the >40 weeks group, a favorable Bishop score (BS ≥3) corresponded with a greater success rate of 21.2%, compared to 12.9% for those with BS <3. The failure rate for BS ≥3 was only 8.5%, substantially lower than the 13.2% reported in the BS < 3 group (Table 7).

Table: 7 Comparison of primary outcome measures based on cervical length with respect to the gestational age in weeks.

S. No	Gestational age		Successful induction (n=316)		Failed induction (n=106)	
			n	%	n	%
1	37 – 39 weeks (n=163)	CL ≤ 3.05	53	16.8	20	18.8
		CL > 3.05	49	15.5	41	38.7
2	>39 – 40 weeks (n=128)	CL ≤ 3.05	50	15.8	9	8.5
		CL > 3.05	56	17.7	13	12.3
3	>40 weeks (n=131)	CL ≤ 3.05	56	17.7	10	9.4
		CL > 3.05	52	16.5	13	12.3

The results of a study of induction outcomes and cervical length (CL) with respect to gestational age show a link between cervical length and induction success. In the 37-39 weeks group, women with a cervical length of 3.05 cm or below (CL < 3.05) had a 16.8% success rate (53/316) and an 18.8% failure rate (20/106). In contrast, women with a cervical length greater than 3.05 cm (CL > 3.05) had a slightly lower success rate of 15.5% (49/316), but a much higher failure rate of 38.7% (41/106). In the >39-40 week group, those with CL ≤ 3.05 had a success rate of 15.8% (50/316) and a failure rate of 8.5% (9/106), but those with CL > 3.05 had a greater success rate of 17.7%

(56/316) and a failure rate of 12.3% (13/106). Similarly, in the >40 weeks group, the success rates were comparable: 17.7% (56/316) for CL < 3.05 and 16.5% (52/316) for CL > 3.05. The failure rate for CL ≤ 3.05 was 9.4% (10/106) and somewhat higher at 12.3% (13/106) for CL > 3.05 (Table 8).

Table: 8 Correlation of cervical length and Bishop score with the various time intervals estimated from induction in the study.

S.No	Correlation of	With	Pearson's r value	R square	P value	Interpretation
1	Cervical length	Bishop score	-0.35	0.123	<0.0001*	Negative association with weak strength
2	Cervical length	Induction to active phase	0.269	0.07	<0.0001*	Positive association with negligible strength
3	Cervical length	Induction to delivery interval	0.27	0.07	<0.0001*	Positive association with negligible strength
4	Bishop score	Induction to active phase	-0.31	0.09	<0.0001*	Negative association with weak strength
5	Bishop score	Induction to delivery interval	-0.3	0.09	<0.0001*	Negative association with weak strength

The study's assessment of primary outcome measures based on several diagnostic parameters reveals that Bishop score and cervical length are effective predictors of successful induction. The Bishop score (≥3) predicted successful induction by 82.2%, resulting in 212 successful inductions and 46 failures. In comparison, when the Bishop score was absent, 104 inductions were successful and 60 failed. The Bishop score (≥3) was significantly associated with effective induction, with a relative risk of 1.3 ($p < 0.0001$). Cervical length (<3.05 cm) predicts effective induction by 80.3%. When cervical length was ≤ 3.05 cm, 159 inductions were successful and 39 failed. However, when cervical length was lacking, 157 successful inductions and 67 failures were recorded. The relative risk of cervical length was 1.14 ($p=0.018$), indicating a statistically significant association with induction success (Table 9).

Table: 9 Comparison of primary outcome measures between the type of diagnostic parameters used in the study.

S. No	Intervention method		(outcome) Successful induction		Relative risk (p value)	Positive prediction of successful induction
			Present	Absent		
1	Bishop score (≥3) alone	Present	212	46	1.3 (p<0.0001*)	82.2%
		Absent	104	60		
2	Cervical Length (<3.05 cm) alone	Present	159	39	1.14 (p=0.018*)	80.3%
		Absent	157	67		

Assessing the Combined Effect of Bishop Score (BS) and Cervical Length (CL) by TVS in Predicting the Outcome

The combined effect of Bishop score (BS) and cervical length (CL) on the outcome of induction was analyzed in 422 women. For those with a Bishop score less than 3 (BS <3), when the cervical length was ≤ 3.05 cm, 34 women (68%) had a successful induction. However, when cervical length was > 3.05 cm, the success rate increased to 61.9% with 70 out of 113 women achieving a successful induction. For women with a Bishop score of ≥3 (BS ≥3), the outcomes were more

favorable. When cervical length was ≤ 3.05 cm, the success rate was 84.5%, with 125 successful inductions out of 148 women. For those with cervical length > 3.05 cm, the success rate remained high at 78.4%, with 87 out of 111 women experiencing a successful induction.

Neonatal Outcomes and SNN Admission Reasons

The neonatal outcomes observed in the study indicated a mean birth weight of 2.83 kg with a standard deviation of 0.41 kg, ranging from 1.8 kg to 4.5 kg. The mean Apgar score at the first minute was 7.1, with a standard deviation of 0.66, and ranged from 4 to 8. At the fifth minute, the mean Apgar score improved to 8.21, with a standard deviation of 0.57, ranging from 6 to 9. Regarding Special Newborn Nursery (SNN) admissions, 52 babies (12.3%) were admitted, while 370 babies (87.7%) were not. The reasons for SNN admission were varied, with the most common being low birth weight (LBW), which accounted for 25% (13/52) of the admissions. Other notable reasons included respiratory distress syndrome (RDS) and intrauterine growth restriction (IUGR), each contributing to 19.2% (10/52) of the admissions. Asphyxia, meconium-stained amniotic fluid (MSAF), and gestational diabetes mellitus (GDM) in the mother were less common but still significant, representing 7.7%, 5.8%, and 5.8%, respectively. In some cases, multiple conditions were noted, such as RDS combined with MSAF or LBW combined with MSAF.

Maternal Complications

The study observed a variety of maternal complications during labor and delivery. The majority of women (92.2%, 389/422) experienced no complications. Among the complications, the most common was atonic postpartum hemorrhage (PPH), which occurred in 4.5% (19/422) of cases. Perineal laceration was noted in 2.8% (12/422) of women. Traumatic PPH was observed in 0.2% (1/422), and the combination of perineal laceration and traumatic PPH was also recorded in 0.2% (1/422) of the participants (Fig.7).

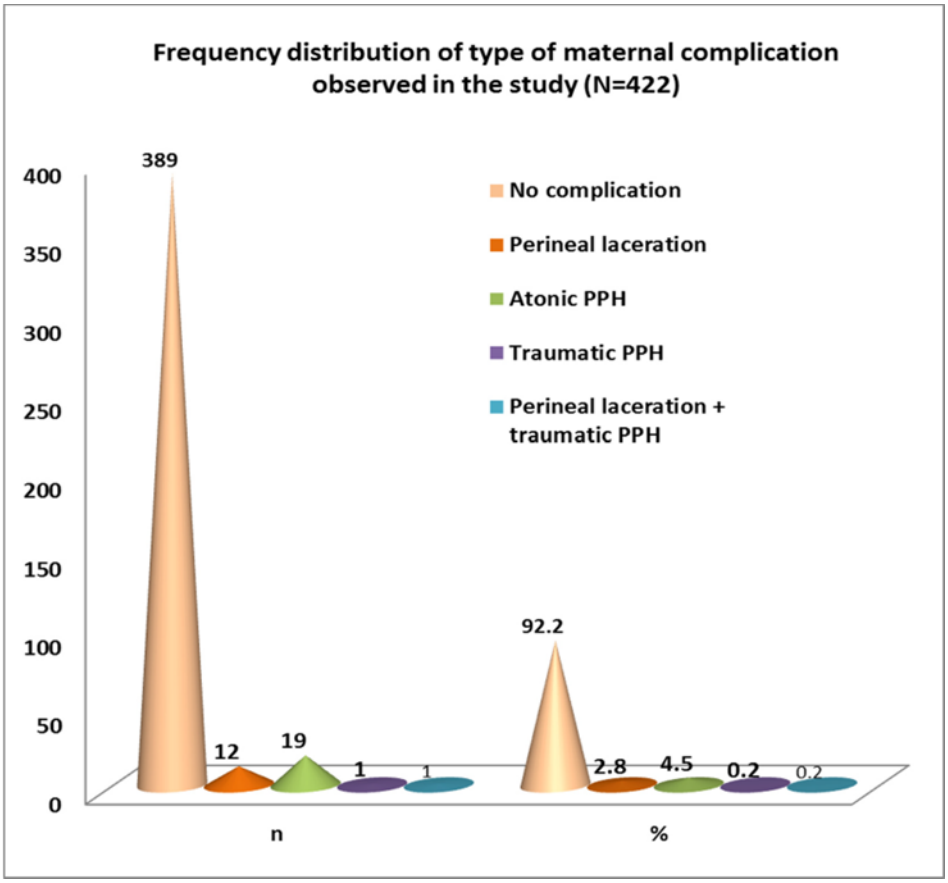


Figure: 7 Vertical cone diagram representing the frequency distribution of type of maternal complication observed in the study.(N=422)

DISCUSSION

Our study demonstrated that both cervical length (CXL) and Bishop score (BS) are effective predictors of successful induction of labor in nulliparous women. The results indicate that CXL is a valid alternative to BS for predicting labor induction outcomes, given that the positive predictive values (PPV) of both are nearly identical. While studies on the predictive value of pre-induction sonographic cervical length measurements have yielded conflicting results, our findings support the use of CXL as a comparable tool to BS.

Comparison with Previous Studies

Several previous studies have investigated the value of cervical length and Bishop score in predicting induction success, although they have reported mixed outcomes. Balaji et al. (2016) found that cervical length was a stronger predictor of successful induction compared to the Bishop score, with cervical length better correlating with induction success. Balaji et al.'s results also suggested that the Bishop score did not reliably predict the induction-to-delivery interval, which aligns with our own study's findings [9]. In contrast, Khandelwal et al. (2016) studied 66 primigravid women and concluded that the Bishop score was superior to cervical length for predicting induction success [10]. Their study used a combination of mechanical methods and vaginal misoprostol for labor induction, which may have influenced the induction-to-delivery interval and altered their results compared to ours. In our study, we adhered to our hospital's protocol, which did not aim to shorten the time between induction and delivery.

Khazardoost et al. (2016) reported that a Bishop score greater than 4 predicted successful induction within 6 hours, with a sensitivity of 69% and specificity of 79% [11]. They also found that a cervical length of less than or equal to 25mm had a sensitivity of 51% and specificity of 70% for predicting successful induction. This differs from our study, which focused on vaginal delivery within 24 hours instead of 6 hours, making direct comparisons of the cut-off values difficult. In our study, we used a Bishop score cut-off of ≥3 and cervical length cut-off of ≤3.05 cm, with sensitivity and specificity values differing somewhat from the findings of Khazardoost et al.

In contrast, Sinha et al. (2024) studied 100 primigravida and found that when combined with cervical length measurements via transvaginal ultrasound, the Bishop score could predict induction success. A Bishop score of 5 and cervical length of 2.8 cm were used as cut-off values [12]. However, Sinha et al. did not evaluate time intervals such as the induction-to-delivery interval, which limited their ability to make direct comparisons with our study. Similarly, Daskalakis et al. (2006) studied 137 women and found cervical length to be a good predictor of induction success, with a cut-off value of <27 mm yielding sensitivity and specificity rates of 76% and 75.5%, respectively [13]. This contrasts with our findings of a lower sensitivity for cervical length (50.3%) and specificity (63.2%).

Pandis et al. (2001) studied 240 women and also found that cervical length measured by transvaginal ultrasound predicted the likelihood of vaginal delivery within 24 hours of induction. Their study reported a best cutoff point of 28 mm for cervical length and 3 for Bishop score, with sensitivities of 87% and 58%, respectively, and specificities of 71% and 77% [14]. These results are similar to our study's findings in terms of specificity, although their sensitivity rates were notably higher.

Success Rates and Cut-off Values

Our study included 422 participants, with 74.9% successful induction and 25.1% failure. These findings are congruent with those of Balaji et al. (2016) and Khandelwal et al. (2018), who found successful induction rates of 85% and 83.3%, respectively [9, 10]. However, Sreegouri et al. (2015) attained a 90% success rate, although Daskalakis et al. (2006) and Pandis et al. (2001) reported lower success rates of 67.1% and 80.4%, respectively [13, 14]. Regarding the cut-off values, our study used a Bishop score of ≥3 and a cervical length of ≤3.05 cm. Other studies employed different cut-offs, such as ≥4 (Balaji et al.), ≥5 (Khandelwal et al.), and >5 (Sreegouri et al.) [9, 10, 15]. For cervical length, our study's cut-off was ≤3.05 cm, whereas other studies used cut-offs ranging from

≤2.5 cm to ≤2.8 cm. These differences in threshold values highlight the variability across studies in defining what constitutes a "successful" pre-induction measurement.

Sensitivity and Specificity

In terms of diagnostic characteristics, our study's sensitivity for cervical length was 50.3%, which was lower than that of Sreegouri et al. (76%) and Daskalakis et al. (87%). However, our study's specificity (63.2%) is within the range reported by Balaji et al. (70%) and Sreegouri et al. (75.5%), showing that our findings are consistent with the broader literature [13,9,15]. Sensitivity relates to a test's ability to correctly identify individuals who will pass the induction, whereas specificity refers to the ability to identify those who will fail the induction. Our results suggest that cervical length is not as sensitive in predicting successful induction as other studies have reported, which could be due to differences in induction methods and protocols.

Induction-to-Delivery Interval and Associations

Our study also looked at the relationship between cervical length and the induction-to-delivery (I-D) interval, which was determined to be positive. This is consistent with most other studies that found a relationship between cervical length and I-D interval, with the exception of Daskalakis et al. (2006) and Pandis et al. (2001), which found no such association [13, 14]. Similarly, our analysis found a significant connection between Bishop score and the I-D interval, which is consistent with the findings of Khandelwal et al. (2016) and Sreegouri et al. (2015) [10, 15]. However, this connection was not detected in Daskalakis et al. (2006) or Pandis et al. (2001), implying that induction techniques may play an important role in these results [13, 14].

Cervical Length as a Predictor

Several studies have explored cervical length as a predictor of induction success. For example, Tendean., 2015 found a significant correlation between cervical length and successful induction within 24 hours, with an optimal cut-off of ≤2.895 cm and a sensitivity of 79.41% and specificity of 80% [16]. In contrast, Groeneveld et al. (2016) concluded that transvaginal ultrasound measurement of cervical length was not an independent predictor of vaginal delivery within 96 hours [17]. However, they did find that the Bishop score was a reliable independent predictor. Maren Shapiro., 2015 conducted a meta-analysis of five studies with 735 gestations, showing a strong inverse relationship between cervical length and delivery within one week, with a sensitivity of 65% and specificity of 60% for cervical length less than 30 mm [18]. Other investigations, including those by Yanik et al. (2007) and Khazardoost et al. (2022), discovered cervical length to be a reliable predictor of induction success [19, 20]. Their investigations used comparable cut-off values for cervical length and discovered excellent sensitivity and specificity, showing that cervical length measures can assist predict effective induction, especially when paired with additional markers such as the Bishop score.

CONCLUSION

In conclusion, both cervical length and Bishop score are useful predictors of successful labor induction, but their efficacy varies depending on the protocols followed and the patient type. Our findings are similar with many other studies, however there are significant variances in the cut-off values, sensitivity, and specificity of these measures. While cervical length and Bishop score have advantages and disadvantages, they can be utilized in tandem to improve the prediction of labor induction results. Further research is needed to standardize the protocols and refine the cut-off values to optimize prediction accuracy and patient outcomes. Further research with larger sample sizes and standardized techniques is needed to refine the thresholds for cervical length and Bishop score, as well as to investigate potential combinations of these criteria for more precise labor induction outcomes.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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