

Correlating the Accuracy of Colposcopy with Practitioner Experience when Diagnosing Cervical Pathology Using the Dynamic Spectral Imaging System

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Key Words

Experience · Colposcopy · Sensitivity · Cervical intraepithelial neoplasia · Dynamic spectral imaging

Abstract

Background/Aims: To assess the performance of colposcopists and correlate it with their experience when diagnosing cervical pathology by reviewing conventional colposcopy (CC) digital images and the Dynamic Spectral Imaging System (DySIS) cervical map. **Methods:** Images from 50 women with normal and abnormal cervix collected during CC and the corresponding DySIS maps were projected consecutively to 63 participating colposcopists. Participants were asked for their diagnosis (normal, abnormal findings or cancer). The clinical experience of the participants was divided into low ($n = 27$), medium ($n = 18$) and high ($n = 18$), considering the number of colposcopies each one performed routinely. **Results:** The mean of overall correct diagnoses was significantly higher with DySIS than CC for the low and medium experience group (20.4 vs. 24.4, and 21.9 vs. 26.0, respectively; $p < 0.001$), but not in the high experience group. The correct diagnosis was significantly higher with DySIS than CC for all experience groups in cases with a normal cervix and cervical intraepithelial neoplasia 2+ (CIN2+), but not for those with CIN1. All groups agreed that DySIS guides biop-

sies better, offers more information and allows performing colposcopy even without extensive experience. **Conclusions:** The results of evaluating projected colposcopy images were more successful with DySIS than with CC in the diagnosis of cervical pathology, especially among less experienced colposcopists.

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Introduction

Cervical cancer is the second most common malignant neoplasm in women worldwide [1]. Introduction of the Pap smear in cervical cancer screening programs has achieved a reduction in mortality of this neoplasm, although its overall sensitivity does not reach 65% [2].

Colposcopy with 3% acetic acid is recommended after an abnormal pap screening test result, an HPV-DNA test positive for 16/18 genotype with negative Pap smear, or for presence of a palpably or visually abnormal cervix, vagina, or vulva. However, conventional colposcopy (CC) has a low sensitivity and is a subjective technique that

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should be performed by trained personnel [3]. The latest colposcopic classification intends to improve its performance [4]; however, the correct diagnosis in colposcopic examination can be as low as <55% even for cervical cancers [5]. Colposcopy is unsatisfactory in 10–20% of the patients, and this is a cause of inaccuracy. Estradiol and misoprostol have been useful in overcoming unsatisfactory colposcopy in more than 70% of the cases [6]. The accuracy of CC has been associated with the competence of the colposcopist to recognize and compare the various patterns shown by the different grades of cervical lesions. In itself, CC is not a diagnostic method, but is the way to perform a biopsy, which is the gold standard for assessing the condition of the cervix. However, the final histological diagnosis will always depend upon the decision of the colposcopist to take a biopsy and his/her ability to identify the best site to sample. Expert colposcopists take samples from the most atypical areas, performing only the necessary biopsies and proper LLETZ [7, 8]. Clinical competence depends on appropriate training and maintenance of long-term experience [9–11]. The clinical inexperience and the coexistence of more than one grade and type of cervical lesions with different colposcopic appearance increase the risk of biopsy sampling errors during colposcopy [12, 13].

In order to improve the precision and accuracy of the colposcopic procedures, a new colposcopic system has been developed that may be more helpful in diagnosis. The Dynamic Spectral Imaging System (DySIS; DySIS Medical Ltd., Livingston, UK) has demonstrated to be more sensitive than colposcopy in detecting high-grade cervical intraepithelial neoplasia 2+ (CIN2+) lesions and improving the selection of cervical biopsy sites [14]. It is a digital colposcope that can be used to perform CC and also measures the dynamic color changes associated with cervical lesions after the application of acetic acid. During the examination, the software that is embedded in the device calculates and displays a color-coded map that represents not only the localization, but also reflects the severity of the cervical lesion, indicating the best areas for biopsies [15, 16]. It has been demonstrated that when the DySIS map is integrated in the colposcopic examination, the colposcopic sensitivity to detect high-grade disease increases significantly [15]. With these possibilities, colposcopy with the DySIS appears as a procedure that is easy to perform, even for practitioners with low expertise.

The aim of this study is to analyze how colposcopic experience influences the accuracy in diagnosing the different conditions of the cervix by reviewing CC images and the DySIS map for a series of cases.

Materials and Methods

Sixty-three colposcopists were asked to participate in this study (all at the same time) during a meeting related to low track diseases and colposcopy at Hospital Clínico San Carlos, Madrid, Spain. All participants consented to participate in the study. They all had previous colposcopic experience of varying levels and all had been trained previously (during that meeting) by an experienced colposcopist in the latest terminology classification of the International Federation for Cervical Pathology and Colposcopy [4]. It was also explained to them how to interpret the different colors of the DySIS map. None of the participants had any previous experience with DySIS.

During the test, they were asked to predict the final diagnosis of cervical pathology in the 50 colposcopic cases shown to them. All images were from patients that had been referred to colposcopy because of an abnormal cervical smear or indications suggesting the possibility of cervical neoplasia. This study has been approved by the local ethics committee as part of the 'DySIS study' (C.P. DYSIS – C.I. 13/314-E).

The colposcopic images were projected on a large screen for all participants. Projection of colposcopic images has been shown to be a good representation of the colposcopic examination without impairing the diagnostic accuracy [17], and the high quality images that were collected with DySIS ensured the minimal loss of information.

Two expert colposcopists had selected the cases consecutively, and included 20 normal or with metaplasia, 16 with CIN1 and 14 with CIN2+ as confirmed by final pathologic diagnosis obtained by punch biopsy or LLETZ. Biopsies had been taken in abnormal areas identified either by CC or DySIS. When a LLETZ was performed and there were differences in the diagnosis, the higher grade was chosen as ground truth. The actual colposcopic procedures had been performed and documented by an expert colposcopist using DySIS in the colposcopy unit of the Hospital Clínico San Carlos, according to previous descriptions and the indications of use of the device [14]. After colposcopy, all patients received the standard of care.

For each and every case, the participants were first shown a high-quality digital image of CC, which was then followed by the corresponding color-coded map obtained by the DSI technology (fig. 1). Both types of images from the same patient could be obtained because the DySIS instrument enables the user to perform both CC and dynamic spectral imaging assessment and mapping of the cervix. While reviewing the images, the participants were blinded to the referral reason of the patients and also did not know the final histological results.

After reviewing each image, the participants were invited to select one of the following four probable results for that case: normal/metaplasia, low-grade lesion, high-grade lesion or cancer. Selecting the correct answer from the four possible options was considered as a success for that case. At the end of the presentation, an opinion questionnaire was administered with the following questions: Is the interpretation of DySIS easier than standard colposcopy?; Does DySIS orient better my diagnosis?; Does DySIS direct better my biopsy site selection?; Do you believe that DySIS offers more information than standard colposcopy?; Do you believe that DySIS allows to perform a colposcopy without experience?; And Do you believe that DySIS is better than standard colposcopy? The answers were graded on a visual scale as 1 (complete disagree-

Fig. 1. Example of a case shown in the test. **a** Image corresponds to CC. **b** Image represents the corresponding DySIS map overlaid on the cervix. Both images were shown consecutively during the test. This case was histologically confirmed as CIN2–3.

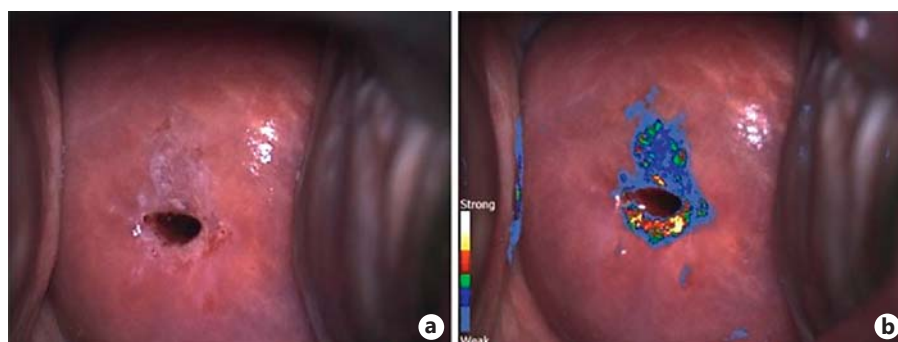


Table 1. Number of successful responses in the colposcopic test stratified by colposcopic experience

	n	CC	DySIS	Difference ^a	p value
First-year resident	10	19.6 (18.4–20.8)	25.5 (23.0–27.9)	+11.8%	0.002
Second-year resident	9	22.1 (19.4–25.1)	22.8 (18.6–26.9)	+1.4%	0.576
Third-year resident	8	19.5 (16.7–24.3)	25.0 (21.7–28.3)	+11%	<0.001
Fourth-year resident	6	22.0 (18.6–25.4)	28.0 (26.8–29.1)	+12%	0.001
Gynecologist with low CE	12	21.8 (19.9–23.8)	25.0 (23.9–26.1)	+6.4%	0.023
Gynecologist with high CE	10	22.8 (19.9–25.7)	24.6 (22.3–26.9)	+3.6%	0.299
Accredited colposcopist	8	27.4 (25.2–29.6)	29.0 (25.4–32.6)	+3.2%	0.195
Groups of colposcopic experience					
Low	27	20.4 (18.8–21.9)	24.4 (22.7–26.2)	+8.1%	<0.001
Medium	18	21.9 (20.4–23.4)	26.0 (25.0–27.0)	+8.2%	<0.001
High	18	24.8 (22.8–26.9)	26.5 (24.4–28.7)	+3.4%	0.106

Results are shown as means (95% confidence interval). CE = Colposcopic experience.

^a Percentage of success with DySIS – percentage of success with standard colposcopy.

ment), 2 (disagreement), 3 (agreement), 4 (good agreement) or 5 (fully agree).

Residents in obstetrics and gynecology (whatever year of residency), specialists in obstetrics (whatever level of colposcopic experience), and colposcopists from lower genital tract units accredited by the 'Asociación Española de Patología Cervical y Colposcopia' (accredited colposcopists) participated in the study. In the statistical analysis, the participants were grouped into three colposcopic experience groups: a low experience group (1st-, 2nd- and 3rd-year residents, who perform a low number of colposcopies routinely), a medium experience group (4th-year residents and gynecologists with low colposcopic experience, who routinely perform colposcopies, but not many) and a high experience group (gynecologists with extensive colposcopic experience and accredited colposcopists, who routinely perform colposcopies in their clinical practice). The experience was indicated by each participant in the self-fill questionnaire.

Overall, 6,300 selections (50 pictures in two formats presented to 63 participants) were available for analysis; all answers were introduced in a database and were analyzed using IBM SPSS statistical software version 19. Continuous variables were expressed as mean and 95% confidence interval. For statistical analysis, a t test for related samples (in parametric variables) and Wilcoxon signed

rank test (in nonparametric variables) were used when comparing the result of the survey with each grade of experience. Cronbach's α was used to quantify the reliability of the questionnaire. Statistical significance was defined as $p < 0.05$.

Results

In the 50 cases that presented during the study, the CC had a sensitivity of 84%, a specificity of 72%, a positive predictive value of 52%, and a negative predictive value of 93% for the detection of CIN2+, while the interpretation of DySIS map had a sensitivity of 84%, specificity of 89%, positive predictive value of 88%, and negative predictive value of 73%. Overall, the median value of successes was 22.7 ± 4.1 in CC and 26.3 ± 3.6 in DySIS (mean difference 15.9%; $p < 0.001$).

The type of colposcopists participating in the study has been summarized in table 1. The coefficient of internal

Table 2. Number of successful selections stratified by grade of cervical pathology

Colposcopic experience	n	CC	DySIS	Difference ^a	p value
Normal/metaplastic (n = 20)					
Low experience	27	7.0 (5.5–8.3)	10.5 (8.6–12.3)	+17.6%	<0.001
Medium experience	18	8.4 (6.7–10.1)	13.3 (11.9–14.7)	+24.7%	<0.001
High experience	18	11.1 (7.6–9.5)	13.8 (12.0–15.6)	+13.6%	0.004
CIN1 (n = 16)					
Low experience	27	7.8 (6.8–8.8)	6.8 (5.7–7.8)	–6.3%	0.037
Medium experience	18	7.9 (7.1–8.7)	6.6 (5.8–7.4)	–8.0%	0.023
High experience	18	8.5 (7.5–8.6)	6.7 (5.5–7.8)	–11.5%	0.010
CIN2+ (n = 14)					
Low experience	27	4.5 (3.6–5.4)	5.8 (5.2–6.4)	+9.3%	<0.001
Medium experience	18	4.3 (3.4–5.3)	5.6 (5.1–6.0)	+9.2%	0.023
High experience	18	4.2 (3.5–4.9)	5.8 (5.1–6.4)	+11.4%	0.001

Data are shown as means (95% confidence interval).

^a Percentage of success with DySIS – percentage of success with CC.

consistency of the test for interpretation of the 50 cases and the opinion survey about the DySIS experience was high (Cronbach's $\alpha = 0.9962$ and 0.9691 , respectively).

Table 1 shows the median value of successes in the answers by medical level and group of experience. 1st-, 3rd- and 4th-year residents and gynecologists with low colposcopic experience presented a significantly better result when they based their decision on reviewing the DySIS map than with just CC ($p < 0.03$); the improvement was not statistically significant for the 2nd-year residents, gynecologists with high experience or expert colposcopists. The low and medium experience groups improved their results with DySIS ($p < 0.001$), but not the high experience group.

The results stratified by histological grade of the CIN are shown in table 2. In both the category of a normal cervix and in high-grade CIN, the mean of success was significantly better with DySIS than CC, independent of the level of colposcopic experience. However, in detecting CIN1, the result with DySIS was worse than CC.

In general, DySIS was well valued by all participants. Participants of the low and medium experience groups were in highest agreement with DySIS. They were in good agreement that DySIS is easier in the interpretation of images, better at orienting the diagnosis, better in suggesting the selection of biopsy site, better in offering information in the diagnosis of cervical lesion than CC. However, the group of high experience did not always agree with these statements. All three groups agreed that DySIS makes colposcopy easier to perform

for clinicians with lower colposcopic experience; however, they did not consider the DySIS map as a better procedure than CC (table 3).

Discussion

The results of this study show that DySIS is a new colposcopic device that seems to enhance the accuracy of the colposcopists in the diagnosis of CIN, especially if they do not have high experience.

Our findings support the belief that nonexperts do not perform colposcopy as well as the specialized clinicians; indeed, the difference in accuracy between the 1st-year residents and the group of accredited colposcopists was almost 40%, indicating that any technology that helps bridge this gap would be welcome; our analysis showed that this difference decreased to 13.7% after using the DySIS map.

The sensitivity of both colposcopic techniques to detect CIN2+ in the included cases at the time of the examination was very high (84%). Although this was not the aim of the study and these results are not reliable enough, the sensitivity of DySIS was similar to that found in previously published clinical trials [14–16].

In the current study, the low and medium experience groups achieved an overall better performance when reviewing the DySIS map than when they observed the CC image. DySIS colposcopy has demonstrated a significantly better sensitivity to detect cervical lesions than CC [15], which implies that it facilitates the diagnosis for the non-

Table 3. Opinion of the professionals about DySIS by colposcopic experience

Questions	Colposcopic experience			p value
	low (n = 27)	medium (n = 18)	high (n = 18)	
Is the DySIS interpretation easier than CC?	4.0 (3.6–4.4)	4.2 (3.7–4.7)	2.8 (2.2–3.5)	0.001
Did DySIS orient better my diagnosis?	4.0 (3.6–4.4)	3.9 (3.4–4.4)	3.2 (2.6–3.8)	0.028
Did DySIS orient better my biopsy site?	4.3 (4.0–4.5)	4.1 (3.7–4.5)	3.7 (3.2–4.3)	0.127
Do you believe that DySIS offers more information than CC?	3.1 (2.6–3.6)	3.5 (3.0–4.0)	2.6 (2.1–3.1)	0.074
Do you believe that DySIS allows performing a colposcopy without experience?	3.4 (2.9–3.9)	3.4 (2.7–4.2)	3.7 (3.2–3.8)	0.731
Do you believe that DySIS is better than CC?	2.8 (2.3–3.3)	2.9 (2.2–3.5)	1.9 (1.5–2.4)	0.030

Data are shown as means (95% confidence interval). Answers were graded as follows: 1 (complete disagreement), 2 (disagreement), 3 (agreement), 4 (good agreement) or 5 (fully agree).

expert colposcopists. These findings could explain our results in the low/medium experience groups. Highly experienced colposcopists are used to identifying the cervical lesion and estimating its grade with CC, while the nonexpert colposcopists are not. However, DySIS can also help the expert colposcopist to better identify cervical lesions, as we observed in this study.

In the accuracy of diagnosis, DySIS was superior to CC to identify a cervix that was normal or a cervix with high-grade CIN. In this study, the participants were less likely to identify CIN1 using DySIS than CC. Low-grade cervical lesions usually appear represented colposcopically as grade 1 abnormal findings, which are less acetowhite than high-grade lesions. In this cases, the DySIS map often showed a blue map color instead of green color, which has been previously defined as usual in low-grade lesions [14]. This could be the explanation why the CIN1 was underestimated by DySIS and the colposcopists did not identify these cervical lesions by using DySIS as accurately as with CC. Previous clinical trials have demonstrated that DySIS alone or in combination with CC improves the detection of high-grade cervical lesions significantly and guides cervical sampling [14, 15]. Furthermore, colposcopy with DySIS achieved a very high sensitivity in the detection of CIN2+ cervical lesions among HPV16 patients as they exhibit more intense acetowhitening [16, 18], which is more easily detected by the DySIS. According to this observation, in our study, the identification of cases with high-grade disease (CIN2+) was significantly improved with the aid of the DySIS map across all colposcopists irrespective of level of experience.

The power of this study, detecting 15.9% in mean difference between the study groups (considering an

α -error of 5 and 95% confidence interval), is higher than 95%.

The opinion that DySIS is more suitable to interpret the cervical findings during colposcopy was shared by all experience groups in our study; however, this opinion was less enthusiastic among participants with high experience. For the nonhigh experience professionals, DySIS was a device easier to understand due to the simple interpretation of the color map. The color-coded map helps new colposcopists to detect cervical lesions and identify the best area to perform a biopsy. Expert colposcopists do not think they need such help because they recognize better the high-grade areas and do not require additional information to do it. However, they also agree that DySIS can direct the diagnosis and biopsy site selection better than CC. An interesting finding was the overall agreement in believing that DySIS can be used by clinicians with very low colposcopic experience. This result was observed when the accuracy of the low and high experience groups was analyzed. The low experience group had a mean of successes 4.4 lower than the high experience group in CC, but only 2.1 lower with DySIS. Adding to this observation, the mean of successes in medium experience group was 2.9 lower than in the high experience group, but only 0.5 lower with DySIS, which indicates that using the DySIS color-coded map can help less experienced clinicians reach a good baseline performance.

This study probably has some bias in the interpretation of images due to neighbor commentaries during the process and the possible distortion of the images due to the projection. Furthermore, the interpretation of the DySIS result may be somewhat underestimated due to

the difficulty to visualize properly the smaller color areas represented in the DySIS map code in the slides, and because the participants had not had prior experience in using or interpreting the color map. Bias related to case selection was minimized by choosing the first consecutive cases with good images that had arrived to the office.

In conclusion, colposcopic assessment using DySIS in projected colposcopy images offers an additional tool that improves the success in the diagnosis of the cervical pa-

thology in comparison to CC. We believe that inclusion of the DySIS map into colposcopy is an easy and intuitive way to improve CC, especially for clinicians with limited colposcopic experience.

Disclosure Statement

The authors declare that they have no conflicts of interest relative to this study.

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