Background: Colonoscopy is the gold standard investigation for the diagnosis of bowel pathology and colorectal cancer screening. Adenoma detection rate is a marker of high quality colonoscopy and a high adenoma detection rate is associated with a lower incidence of interval cancers. Several technological advancements have been explored to improve adenoma detection rate. A new device called Endocuff Vision™ has been shown to improve adenoma detection rate in pilot studies.

Methods/Design: This is a prospective, multicenter, randomized controlled trial comparing the adenoma detection rate in patients undergoing Endocuff Vision™-assisted colonoscopy with standard colonoscopy. All patients above 18 years of age referred for screening, surveillance, or diagnostic colonoscopy who are able to consent are invited to the study. Patients with absolute contraindications to colonoscopy, large bowel obstruction or pseudo-obstruction, colon cancer or polypsis syndromes, colonic strictures, severe diverticular segments, active colitis, anticoagulant therapy, or pregnancy are excluded. Patients are randomized according to site, age, sex, and bowel cancer screening status to receive Endocuff Vision™-assisted colonoscopy or standard colonoscopy on the day of procedure. Baseline data, colonoscopy, and polyp data including histology are collected. Nurse assessment of patient comfort and patient comfort questionnaires are completed post procedure. Patients are followed up at 21 days and complete a patient experience questionnaire. This study will take place across seven NHS Hospital Trusts: one in London and six within the Northern Region Endoscopy Group. A maximum of 10 colonoscopists per site will recruit a total of 1772 patients, with a maximum of four bowel screening colonoscopists permitted per site.

Discussion: This is the first trial to evaluate the adenoma detection rate of Endocuff Vision™ in all screening, surveillance, and diagnostic patient groups. This timely study will guide clinicians as to the role of Endocuff Vision™ in routine colonoscopy.

Study registration: ISRCTN11821044.
cally in the narrower colonic segments, even with the use of a pediatric colonoscope or gastro scope [12, 13]. Currently available transparent caps and hoods, attached at the tip of the scope, have been used to hold down folds and improve visualization in the forward view. However, they make the tip section of the scope more rigid and longer, and this may impair scope insertion in an angulated sigmoid colon [14, 15].

A preliminary pilot evaluation study has demonstrated a potential benefit in terms of mucosal visualization and adenoma detection when using Endocuff Vision™ [16]. Published work on the improved ability to undertake therapy using Endocuff Vision™ has additionally demonstrated advantages gained by obtaining scope tip stability and a safer operational platform [17].

**Endocuff Vision™**

The Endocuff Vision™ (ARC Medical Design Ltd and Diagmed, UK) is a new device (CE marked in UK) made of a soft plastic material with a unique dynamic shape (Fig. 1). The core is made of polypropylene and the ‘finger-like’ projections are made of a thermoplastic elastomer. Endocuff Vision™ comes in four color coded sizes (purple, blue, green and orange) to fit a range of pediatric and adult colonoscopes. The first version of Endocuff Vision™ comprised backwards pointing (proximal and distal to the scope tip) flexible ‘finger-like’ projections at intervals around the device circumference with the following dimensions in different cuff sizes (length of 23.8 mm × diameters of 16.1/16.7/17.2/18.5 mm with the finger-like projections folded back and 32.6/33.1/33.6/34.8 mm with the finger-like projections opened out). The new version of Endocuff Vision™ (the Endocuff Vision™) that is utilized during the clinical trial, however, has only one proximal row of more rounded finger-like projections to eliminate any mucosa lacerations that were observed with the first version (Fig. 2). Both versions are mounted at the tip of the scope and held on by friction (pull-off force is a minimum of 10 Newton). The chief investigators have used the Endocuff Vision™ extensively, and report no occasions of cuff dislodgment. The Endocuff Vision™ aims to improve access in the large bowel by flattening colonic folds and manipulating them away from the field of forward view.

Use of the Endocuff Vision™ is contraindicated in: I. known colonic strictures, or II. active inflammatory disorders such as acute infective colitis, colonic Crohn’s disease, ulcerative colitis, and acute diverticulitis.

Endocuff Vision™ is placed snugly around the colonoscope tip before insertion (Fig. 3). It does not project beyond the tip of the scope, providing an unrestricted view. It does not trap fecal residue. It helps anchor the scope tip against the bowel wall to provide a stable platform of access. The soft, elastic projections are pushed back (recoiled) towards the scope shaft during insertion but evert during withdrawal to hold colon folds away from the field of view.

Endocuff Vision™ may therefore benefit:

1. Patients: More accurate examinations with lower rates of missed polyps. This will ensure that the most accurate endoscopic surveillance program is selected.
2. NHS and other Healthcare providers: Reduced risk, with fewer polyp ‘misses’, and improved ADR, with a potential correlating reduction in interval cancer rates.

**Hypotheses**

We hypothesize that the Endocuff Vision™ will improve ADR by possibly providing better fold retraction, a wider field of view and better scope tip stabilization. We also hypothesize that Endocuff Vision™ may have a positive effect on scope insertion time, cecal or terminal ileal intubation, and patient comfort and satisfaction.

**Primary objective**

The primary objective is to ascertain, if there is a difference in adenoma detection rate between Endocuff Vision™-Assisted Colonoscopy (EAC) and Standard Colonoscopy (SC) patient groups.

**Secondary objectives**

The secondary objectives are:

1. to ascertain, if there is a difference in mean adenomas detected per procedure (MAP2) between EAC and SC;
2. to establish the rate of cuff exchange (that is, how often the cuff has to be removed);
3. to demonstrate non-inferiority of cecal intubation rates and insertion time to cecum between EAC and SC;
4. to demonstrate non-inferiority in complete withdrawal time in procedures where no polyps are detected between EAC and SC;
5. to demonstrate non-inferiority of patient satisfaction with EAC compared to SC;
6. to identify any difference in future colonoscopic workload produced by increased ADR in terms of number of potential follow-up procedures based on British Society of Gastroenterology (BSG) adenoma surveillance guidelines between the EAC and SC groups;
7. to identify the prevalence of proximal sessile serrated polyps between EAC and SC groups;
8. to ascertain the distribution of polyps in the colon in EAC and SC groups by location;
9. to compare the ADR of NHS Bowel Cancer Screening Programme (BCSP) and non-BCSP colonoscopists;
10. to compare the ADR of the first 20% of patients scoped by each colonoscopist with the last 20% of patients in each arm to identify any changes in ADR, and
11. to compare the baseline ADR of each colonoscopist before trial recruitment with their individual ADR in patients where Endocuff Vision™ was not used.

These outcomes will be analyzed on an intention-to-treat basis.

Methods

Study design
This clinical, randomized, multicenter study will be conducted in subjects referred and scheduled for screening or surveillance colonoscopy via the BCSP, diagnostic or surveillance colonoscopy through the symptomatic NHS service, and will compare EAC with SC.

Patients will be recruited from six participating hospital sites within the Northern Region Endoscopy Group and St Mark’s Hospital, London. Recruitment will begin at South Tyneside District Hospital, North Tees Hospital, and St Mark’s Hospital as part of an “internal pilot” for 1 month, to allow for testing of the protocol and data collection process. Any protocol amendments will be disseminated to all participating sites. The study data will be collected and analyzed by the principal investigators. Planned recruitment is for 1772 patients. These patients will have been referred for a colonoscopy at one of the participating sites. All potential participants will be sent or given a patient information leaflet about the study when their colonoscopy paper is sent or given to them, allowing adequate time to read the information leaflet (at least 24 hours) before consenting to the study. On attending the endoscopy unit for their procedure, they will be approached by a member of the research team, and given the opportunity to discuss the study. If they are willing to proceed with the study, they will complete written consent forms, and baseline data will be collected. They will then be randomized to either EAC group or SC group using a computer generated randomization tool. The procedure will be performed, and intraprocedure data collected by a member of the research team onto a data collection process. Any protocol amendments will be disseminated to all participating sites. The study data will be collected and analyzed by the principal investigators. Adverse events will be classified by the research team.

Data collected before colonoscopy:
1. patient demographics (age, gender);
2. indication for colonoscopy, and
3. past abdominal surgical history.

Data collected during the colonoscopy procedure:
1. polyps detected (total number, plus for each polyp seen: location; size; morphology; removed (Yes/No); removal method);
2. extent of examination;
3. insertion time to cecum;
4. insertion time to terminal ileum (if applicable);
5. withdrawal time;
6. position change;
7. use of bowel preparation;
8. use of carbon dioxide insufflation;
9. patient satisfaction and comfort scores, and
10. immediate complications.

Data collected post procedure:
1. polyp histology;
2. complications up to 21 days, and
3. adverse events.

Inclusion criteria
All patients who are attending for screening, surveillance or diagnostic colonoscopy will be invited to the study. Patients should be aged 18 and over and have the ability to give informed consent.

Exclusion criteria
The exclusion criteria are:
1. patients with absolute contraindications to colonoscopy;
2. patients with established or suspicion of large bowel obstruction or pseudo-obstruction;
3. patients with known colon cancer or polyposis syndromes;
4. patients with known colonic strictures;
5. patients with a known severe diverticular segment (that is likely to impede colonoscope passage);
6. patients with active colitis (ulcerative colitis, Crohn’s colitis, diverticulitis, infective colitis);
7. patients lacking capacity to give informed consent;
8. patients on clopidogrel, warfarin, or other new generation anticoagulants who have not stopped this for the procedure;
9. patients who are attending for a therapeutic procedure or assessment of a known lesion, or
10. pregnancy.

Withdrawal criteria
During colonoscopy, Endocuff Vision™ will be withdrawn in situations where:
1. there is an acute angulation in a fixed sigmoid colon rendering scope insertion not feasible with the Endocuff Vision™ mounted;
2. there is a new diagnosis of polyposis syndrome;
3. there is a new diagnosis of active colitis (where the endoscopist is concerned with regard to the risk of mucosal damage);
4. there is identification of a new colonic stricture, or
5. there is a new cancer diagnosis and progression of the colonscope with the Endocuff Vision™ attached is not possible.
**Setting/participating centers**

Seven NHS hospital sites are participating and will enroll patients. Six participating sites within the Northern Region Endoscopy Group are district general hospitals. St Mark’s Hospital in London is a tertiary referral center for endoscopy.

**Randomization**

Patients will undergo stratified randomization into EAC or SC groups based on age, gender, hospital site, and BCSP status. This is done by a computer generated system using a dynamic adaptive algorithm [18] in collaboration with North Wales Organisation for Randomised Trials in Health (NWORTH) Clinical Trials Unit.

**Participating colonoscopists and training with Endocuff Vision™**

Trial recruitment will involve a maximum of 10 colonoscopists at each site, and colonoscopists will be chosen to reflect the range of experience. At each site, a limited number (maximum four) of BCSP colonoscopists will be selected. All colonoscopists at participating units will undergo theoretical and practical sessions of training (using online/DVD tutorials) with Endocuff Vision™ and will have a lifetime experience of at least 20 cases with the device before study commencement. At least one endoscopist from each site will attend the training day where the study will be discussed, use of the Endocuff Vision™ demonstrated and online/DVD tutorials provided for training of other endoscopists.

**Adverse events**

The risks of adverse events (AEs) for EAC are believed to be equivalent to SC, including bleeding and perforation risks. There are also AEs related to sedation such as cardio-respiratory compromise that are similar in both EAC and SC procedures. However, the study will measure AEs, which will be recorded in the patients’ medical notes and on case report forms. AEs will be recorded for the 21-day period from the day of colonoscopy, or until withdrawal from study. Adverse events are defined as any new medical occurrence, or worsening of a pre-existing medical condition in a patient. There are no known complications or AEs from Endocuff Vision™. All AEs will be graded as mild, moderate,

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**Fig. 4** Trial flow chart.

| Prior to trial start: | Site set up: |
|----------------------|-------------|
|                      | Local R&D approvals and SSI forms completed |
| Protocol completed   | Site visit to ensure research nurse support/IT support/endoscopy unit set up appropriate |
| PIS, consent forms, GP letters, invitation letters created CRF, SAE proforma, patient questionnaires created | |
| IRAS completed and REC review completed and ethics approval obtained |

**Training:**

- Identify participating endoscopists
- Offer attendance at central training day (preferably at least PI from each site to attend)
- DVD/web-based resource available for other endoscopists
- Research nurse education on trial/CRF/other paperwork etc

**Internal pilot:**

- St Marks and South Tyneside Hospitals
- 1 month period to test protocol/CRF etc
- Review of process at 1 month – amendments to be made if necessary

**Training/site set up:**

- local R&D approvals etc to continue during internal pilot

**Full trial roll out:**

- After internal pilot
- Roll out to further sites

**Recruitment and data collection:**

- Data collection – procedural on day, patient questionnaires within first week, histology when available, 21-day SAE review

**Review of sample size:** Alterations to case mix as required

**Analysis and write up:**

- Data cleaning, and transfer of completed dataset to Statsconsultancy Ltd
- Data analysis
- Results write up and dissemination

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Bevan Roisin et al. The ADENOMA Study... Endoscopy International Open 2016; 04: E205–E212
or severe, and will be assessed by an Investigator to define the relationship to the Endocuff Vision™.

All Serious Adverse Events (SAEs) will be treated clinically as appropriate and reported to the trial team within 24 hours of the research team becoming aware of the event, using the study-specific SAE Form. Any related and unexpected SAEs will be notified to the main NHS research ethics committee within 15 days of the trial team becoming aware of the event, using the National Research Ethics Service SAE form.

An event will be considered to be serious if it:
1. results in death;
2. is life threatening;
3. results in hospitalization or prolongation of existing hospitalization (exceptions to this are routine planned admissions, including admission for colonoscopy procedures as part of this study);
4. leads to persistent significant disability or incapacity, or
5. is otherwise considered to be medically significant by the Investigator.

SAEs will be recorded and reported from the time of colonoscopy until 21 days following the colonoscopy or until the time of withdrawal. SAEs will be assessed for expectedness, severity, and relatedness to the Endocuff Vision™ device. SAEs will be followed until resolution, death, or until resolution with sequelae. In addition, SAEs must be recorded in the Case Report Form on the Adverse Events section. SAEs will be reported even if they are considered to be expected events or unrelated events by the Investigator.

All AEs and SAEs will be reported and discussed with the Data Monitoring Committee. The Chair of the Data Monitoring Committee will, as appropriate, discuss AEs with two independent clinicians to assess the relationship of these AEs to the Endocuff Vision™ device. The results of this will also be presented to the Trial Steering Committee.
Assessment and follow-up
Clinical follow-up will be as per routine clinical practice for the respective unit. Colonoscopy related complications are routinely recorded up to 21 days post-procedure. All patients will have their post colonoscopy surveillance interval (according to BSG [19] or BCSP [20] guidelines) recorded in the Case Report Form, where appropriate. In the case of incomplete colonoscopy, the reason for this will be recorded. Eligible, consented patients will remain in the study for 21 days following colonoscopy. SAEs will also be reported for the 21-day period post colonoscopy for all patients in the study. We will review complication data and adverse events at 21 days by the most appropriate method for the population at each local site. This will consist of either a telephone call to the patient or review of medical notes and hospital databases. If a patient presents to a different hospital post procedure to the hospital where the colonoscopy was performed, we will contact their General Practitioner to obtain information with regard to the event. This collection of data can occur up to 14 days after the end of the 21-day follow-up period, but will only include data within the 21-day window. No additional visits are required for patients who enter the study. Any follow-up appointments post-colonoscopy will be as per routine care for the respective unit. The timescale for the outpatient appointment and subsequent care will be unaltered by participation in the study.

Sample size
The study is powered to detect a difference in the ADR between two groups. There will be two subgroups of participants – those undergoing colonoscopy via the BCSP, and those with symptoms or being followed up in the general, non-screening, NHS service. ADR varies between these two groups; in the BCSP screening population, ADR is approximately 45%, and in the non-screening population, 16%. A difference in ADR of 5–10% would be of clinical importance (5% in the non-screening cohort, and 10% in the screening cohort).

Preliminary work on BCSP participants at one of the Chief Investigators’ sites suggests that such a rise in ADR for EAC procedures is possible. The proportion of screening to non-screening participants is anticipated to be approximately 20:80. Mean ADR for the whole group is therefore 21.8%, and a 6% increase in ADR to 27.8% is deemed to be clinically significant. Therefore, to demonstrate a 6% increase in ADR with a 5% significance level and 90% power using a one-sided test, it is calculated that 886 patients per group are required for the study, 1772 patients in total (Fig. 6).

Data analysis
The primary outcome is adenoma detection rate. A chi-squared test will be used to compare this outcome between groups. A secondary outcome is the number of adenomas detected per procedure. This is likely to have a positively skewed distribution, and so the Mann-Whitney test will be used to compare between groups. An additional secondary outcome is the proportion of patients who require a follow-up procedure (based on BSG adenoma surveillance guidelines), which will be compared between groups using the chi-squared test.

Other secondary outcomes will be examined on a non-inferiority basis, namely cecal intubation rate, insertion time to cecum, withdrawal time in procedures where there are no polyps, and patient satisfaction. The margin of non-inferiority will be set for all outcomes. For the continuous outcomes, one-sided 97.5% confidence interval for the mean difference between groups will be calculated. For the binary outcomes, a one-sided 97.5% confidence interval for the difference in proportions will be calculated.

Non-inferiority will be assumed if the bound of the confidence interval does not cross the point of non-inferiority. The rate of cuff exchange will be calculated in the EAC group, along with a corresponding confidence interval. The analyses will be performed on an intention-to-treat basis. Data and all appropriate documentation will be stored for a minimum of 15 years after completion of the study, including the follow-up period.

Data monitoring
The trial is supervised by the Data Monitoring Committee which consists of an independent chair, with two independent clinicians and an independent statistician. The aim of the Data Monitoring Committee is to safeguard the interests of trial participants, assess the safety and viability of the intervention during the trial, and monitor the overall conduct of the clinical trial. The Data Monitoring Committee will meet every 4 months.

Trial Management Group
The Chief Investigator has overall responsibility for the study and will oversee all study management. The Trial Management Group will be responsible for the day-to-day running of the trial. The Trial Management Group will be supported by and report to an independent Trial Steering Committee. The Trial Management Group will meet every 2 months.

Trial Steering Committee
The trial is supervised by the Trial Steering Committee which consists of an independent chair, independent clinician, patient and public involvement representative, and also an independent statistician. The role of the Trial Steering Committee is to supervise the trial to ensure that it is conducted to the rigorous stand-
ards set out in the Department of Health’s Research Governance Framework for Health and Social Care and the principles of Good Clinical Practice. The Trial Steering Committee will meet every 6 months.

Publication policy
The Chief Investigators will take responsibility to present and publish the outcomes of the study. Study results will be disseminated through national and international symposia and local networks. The results will also be submitted for publication in international peer reviewed journals and presented to the British Society of Gastroenterology Endoscopy Research Committee, BSG guideline groups and the Bowel Cancer Screening Programme. Feedback will be given to regional and national Endoscopy leads, maximizing the exposure of findings to colonoscopists.

Study period
The study period of this trial is November 2014 to July 2016, with the participant entry period from November 2014 to June 2016.

Protocol version
The trial is on protocol version 14.0 dated 11 November 2015.

Ethical considerations
Ethics approval has been awarded via the NHS Research Ethics Committee before the study starting. There are no known additional risks to patients associated with the use of the Endocuff Vision™ device. The addition of Endocuff Vision™ will not add significantly to the duration of the procedure, although if adenoma detection rate increases significantly, the procedure may take longer due to increased polypectomy numbers. Patients will be informed of the risks associated with standard colonoscopy and consented for the procedures as per standard clinical practice in each center, in addition to a study-specific consent form which will have been discussed with the patient by the research team. The study will be conducted in accordance with the recommendations for physicians involved in research on human subjects adopted by the 18th World Medical Assembly, Helsinki 1964 and later revisions. The ADENOMA Study is supported by the British Society of Gastroenterology Endoscopy Research Committee and has been identified as a research priority. The protocol for ADENOMA study has been reviewed and endorsed by the Bowel Cancer Screening Research Committee.

Sponsor
The trial is sponsored by South Tyneside NHS Foundation Trust District Hospital.

Discussion
Adenomatous polyps can turn into colorectal cancer through the adenoma-carcinoma sequence [21, 22]. Thus, an increase in adenoma detection and subsequent removal may reduce colorectal cancer risk. Methods to improve ADR are widely contested and have been studied via various modalities of technology. This is the first randomized controlled trial looking at the use of Endocuff Vision™ in screening, surveillance, and diagnosis of patients. Studies have shown that there is a wide ADR variation in non-screening colonoscopists with BCSP colonoscopists having a 30% higher ADR comparatively [3, 23]. Although this may in part be due to the increased risk of adenomas in BCSP patients who attend because of a positive fecal occult blood test, this may also reflect higher quality colonoscopy. The Endocuff Vision™ may be of benefit in non-screening colonoscopists to increase ADR. The NHS Bowel Cancer Screening Programme started in July 2006 with all screening endoscopists having to undergo strict accreditation criteria via the Screening Assessor Accreditation System which is a web-based application process maintained by the Joint Advisory Group in Gastrointestinal Endoscopy. All screening colonoscopists must submit audit data demonstrating a high level of performance before accreditation. Completion of an accreditation examination at an independent unit is then undertaken which consists of a multiple choice question examination and performance of two colonoscopies observed by two independent and trained examiners using objective directly observed colonoscopic procedural skills assessment criteria. Accredited colonoscopists are subjects to a rigorous ongoing audit of colonoscopic performance which includes maintaining a minimum of 150 screening colonoscopies annually and having a complication rate below the national average as outlined by the latest national or BCSP data [24]. The quality of BCSP colonoscopy has been reported widely [3]. This study’s strengths are that it is conducted at multiple sites to reflect tertiary and secondary centers. Although a large scale trial, it has a simple patient recruitment process. In addition, use of the Endocuff Vision™ will not unnecessarily lengthen colonoscopy time and no additional NHS resources are required. The minimum of 20 training cases required for completion by each trial colonoscopists ensures that all colonoscopists have a minimum standard from which to progress from. One limitation of this study is that colonoscopists are not blinded to EAC or SC groups. Alternatives that were discussed included having a different colonoscopist perform initial anal intubation or to video record each colonoscopy to be double read by a different colonoscopist after the procedure. However, this was felt to be impractical as the ‘finger-like’ projections of the Endocuff Vision™ occasionally come into luminal view during colonoscopy. The results of this trial will be valuable in determining the role of Endocuff Vision™ in routine colonoscopy.

Trial status
The trial is currently active.

Competing interests: None

Acknowledgments
This study is conducted on existing NHS and BCSP lists, at no extra cost to the NHS. Funding is provided by ARC Medical Design Ltd to cover the Endocuff Vision™ devices, clinical trial unit costs, and results analysis. The two chief investigators are currently full-time dedicated clinical researchers. Principal investigators will be supported by a research team (of research fellows and/or research nurses) and they will invite, assess, and consent participants, and collect data. No additional NHS resources will be required to conduct this study. Any unforeseen costs related to the study will be met by ARC Medical Design Ltd. We would like to acknowledge members of the Data Monitoring Committee – Professor Mike Bramble, Professor John McLaughlin, Dr Anjan Dhar, and Dr Ben Carter for their participation and

Bevan Roisin et al. The ADENOMA Study... Endoscopy International Open 2016; 04: E205–E212
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