Original Article

Post-operative effectiveness of continuous wound infiltration, continuous epidural infusion and intravenous patient-controlled analgesia on post-operative pain management in patients undergoing spinal surgery

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ABSTRACT

Background and Aims: Very few studies have compared continuous wound infiltration (CWI), continuous epidural infusion (CEI) and intravenous Patient Controlled Analgesia (PCA) with morphine in spine surgery. This study compared these modalities in patients undergoing microdissectomy. **Methods:** This prospective, randomized control trial was conducted on 75 patients of American Society of Anesthesiologists' physical status I or II undergoing microdiscectomy. Patients in all the three groups received morphine 1 mg IV, with a lockout period of 10 min after each bolus, and the maximum allowed dose was 15 mg/5 h postoperatively. Patients in Group A received CWI with 0.25% levobupivacaine 20 mL as bolus after extubation followed by infusion at 5 mL/h. Group B received CEI with 0.25% levobupivacaine at 5 mL/h. Patients in Group C received intravenous (IV) morphine by PCA pump only. The primary end points were static and dynamic visual analogue scores (VAS) and postoperative pain scores. Secondary observations were postoperative morphine consumption at 8 h, 24 h and 48 h, and patient satisfaction. **Results:** Group A showed greater analgesic effects at 12 h ($P < 0.02$), 24 h ($P < 0.03$), 36 h ($P < 0.008$) and 48 h ($P < 0.007$) when compared to the other two techniques, as pain scores were less in group A as compared to group B and C. The requirement of postoperative intravenous morphine (mg) was 18 ± 12.82, 22.92 ± 9.88, 41.56 ± 8.83 for groups A, B and C after 48 h ($P < 0.001$). **Conclusion:** Continuous wound infiltration is an effective postoperative pain control technique with minimal side effects, after spinal surgery.

Key words: Continuous wound infiltration, epidural analgesia, patient-controlled analgesia, surgery, spine

INTRODUCTION

Microdiscectomy is performed in symptomatic patients whose disabling pain and functional impairment have failed to respond to adequate trials of conservative treatment. Postoperative pain derived from this minimally invasive procedure can further cause discomfort and if persistent, may lead to chronic pain.[1]

Complex multifactorial mechanisms may provide impetus for chronic pain to develop from continuous nociceptive process.[2] In an effort to improve pain control, evidence-based multimodal analgesia techniques involving administration of analgesics through different modalities acting at different sites within the central and peripheral nervous have been implemented.[3] The use of regional anaesthesia and analgesia to inhibit the neural

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conduction from the surgical site to the spinal cord and decrease spinal cord sensitisation is an important part of multimodal analgesia.[4]

It was hypothesised that administration of local anaesthetics in the subcutaneous plane at the surgical site would result in the spread of drug further, thus blocking nociceptive inputs. Owing to lack of prospective trials comparing the efficacy of the three modalities, we designed this study with the aim of comparing the quality of post-operative pain relief that can be achieved with three techniques, namely, continuous epidural infusion (CEI), continuous wound infiltration (CWI) and intravenous (IV) patient-controlled analgesia (PCA). We also aimed to determine the patient's understanding and acceptance of these techniques, in terms of satisfaction, sleep quality and readiness for future repetition, as well as any side effects associated with these techniques.

METHODS

The study was conducted in a tertiary care teaching hospital over a period of 15 months. After obtaining approval from the institutional ethics committee and taking informed consent from the participants, this prospective, experimental, randomised study was conducted in 75 patients of either sex belonging to the American Society of Anesthesiologists' physical status I or II. Patients posted for single-level lumbar discectomy under general anaesthesia with history of chronic low back pain persistent up to 6 months in spite of alternative therapies and treatments were included in the study. Patients with body mass index greater 35 kg/m^2, those with coagulation disorder, presence of infection at surgical site, allergy to any drug used under protocol, patients suffering with cardiovascular disease or asthma, contraindications to epidural analgesia if present, all those patients who had any surgical drain at surgical site, patients unable to comprehend pain scales or to use the PCA device, patients on chronic morphine therapy and drug abusers were excluded. Patients on medications for neuropathic pain like pregabalin and gabapentin were required to discontinue the same for 14 days before surgery.

A total of 75 patients were randomly divided into three groups (Groups A, B and C) using a computer generated programme. Assigned random groups were enclosed in a sealed envelope to ensure concealment of allocation sequence. The assigned anaesthesia technician, who was not involved in the study opened the envelope, maintained the randomisation chart and prepared drugs accordingly. All patients were anaesthetised by the same anaesthesiologist and operated by same surgeon.

Patients in Group C (*n* = 25) received only IV PCA morphine 1 mg IV, with a lockout period of 10 min after each bolus, and the maximum allowed dose was 15 mg/5 h and no background infusion. Patients in Group A (*n* = 25) received continuous wound instillation of 0.25% levobupivacaine (0.5% levobupivacaine 30 mL mixed with 30 mL distilled water). A 20 mL bolus was given initially, and an infusion was then started at 5 mL/h. Patients in Group B (*n* = 25) received CEI of 0.25% levobupivacaine (0.5% levobupivacaine 30 mL mixed with 30 mL distilled water) 10 mL bolus and infusion started at the rate of 5 mL/h.

After thorough pre-anaesthetic evaluation, the patients were explained about the analgesic system they would use after surgery and post-operative pain questionnaires. On the night before surgery, the patients were premedicated with oral midazolam 7.5 mg, oral, ranitidine 150 mg and oral metoclopramide 10 mg with small sips of water.

Before shifting the patient to the operation theatre, in the pre-anaesthetic reception lounge, skin sensitivity test was done with local anaesthetic solution to be used. Electrocardiograph, non-invasive blood pressure, pulse-oximeter, capnograph and temperature were monitored using Drager Infinity Vista® monitor (Model MS14750E5394). After shifting the patient inside the operation theatre an IV line was secured and Ringer Lactate infusion was commenced. The patient was preoxygenated with 100% oxygen for three minutes. Anaesthesia was induced using fentanyl 2µg/kg IV and propofol 2.5 mg/kg IV; after confirmation of ability to ventilate the patient vecuronium 0.1 mg/kg IV was given. Positive pressure ventilation was provided for three minutes and the patient was intubated with appropriate size endotracheal tube.the endotracheal tube was secued after confirming correct placement by bilateral chest auscultation and capnography.

All the patients were operated in prone position with 20° head up and neck in flexed position with head resting on silicone head rest. Anaesthesia was maintained with a combination of oxygen, nitrous oxide and isoflurane at 1–1.5 minimum alveolar concentration (MAC) with intermittent top-ups of

vecuronium IV and fentanyl IV. All the patients were administered paracetamol 1.0 g IV 15 min before the end of surgery.

In Group A, after closure of aponeurosis the surgeon implanted a multiloculated clear catheter with 3 lateral eyes, (Smiths Medical) 18 G in diameter (ref no 100/382/118) into the surgical wound, approximately 4 cm below the end of the incision. After the patient was turned supine drug dose was started by flushing the wound with 20 mL of 0.25% levobupivacaine and then a CWI was started at 5 mL/h.

In Group B, before closure, the surgeon placed an epidural catheter in the epidural space through a tunnel made 5 cm lateral to upper end of the incision and catheter passed subcutaneous and under the muscle and placed just over the durameter under vision, the catheter was fixed on the skin using 2-0 silk suture and incision was closed around it. After the patient was turned supine, patient was administered 0.25% levobupivacaine 10 mL and an infusion was started at 5 mL/h.

The correct placement of catheters was checked with portable X-ray of the spine at the end of the procedure. The catheters in Group A and B were covered with sterile dressing and plaster tape which was separated from wound dressing to avoid dislodgement of catheter. After completion of surgery, residual neuromuscular blockade was antagonised and the trachea was extubated.

The catheters were fixed in place for 48 h. In all the three groups, patient's post-operative pain relief was achieved by PCA pump (Fresenius Master Serial no 054190/21450985) by giving morphine 1 mg IV, with a lockout period of 10 min after each bolus, and the maximum allowed dose was 15 mg/5 h. Tramadol 2 mg/kg IV was given as rescue analgesia.

The primary outcome measure was the static and dynamic visual analogue score (VAS) and post-operative pain score (PPS) and the requirement of rescue analgesic over a period of 48 h. No patient was withdrawn from the study because of severe pain requiring additional analgesic beyond the recommended protocol. Patients were evaluated by the visual analogue score (0 - no pain, 1–3 mild pain, 4–7 moderate pain, 8–10 - severe or worst imaginable pain) and PPS (0 = no pain; 1 = moderate pain only when moving; 2 = moderate pain at rest, severe pain when moving and 3 = constant severe pain) were recorded at time 0 min, 30 min, 1 h, 6 h, 12 h, 24 h, 36 h and 48 h postoperatively. The pain scores were used to evaluate the quality of analgesia in two situations: static pain when the patients were restricted in bed, and dynamic pain during log rolling in bed 6 h after operation. For log rolling, help of nursing staff was taken. The patient was supported from all four sides with one person supporting the neck. The patient was then turned to first right side up to 90°, then made supine and turned similarly to the left side. Care was taken at all times to avoid flexion of spine and any unsynchronised movement of the limbs.

The secondary outcomes were patient satisfaction and quality of sleep which were graded from 0 to 3 points: unsatisfactory, regular, satisfactory and excellent. Future repetition of the technique was recorded as 0 for does not know, 1 for no and 2 for yes.

The evaluation of undesirable effects and complications (nausea and vomiting, pruritus constipation and urinary retention) also followed the same periodicity and were recorded as present or absent. All the recordings were done by nursing staff. Sedation was measured by Ramsay sedation score.[5] Close attention was paid to the wound healing by both surgical and anaesthesia team in the post-operative care to detect any excessive inflammatory reaction or infection. The catheter insertion site, neurological examination and motor examination were assessed carefully.

The sample size was estimated on the basis of previous published data. We used G power software to calculate the sample size with $\alpha = 0.05$ and power at 80%, in the absence of prior knowledge of effect size at the time of study. Cohen criteria was used for repeated measure design (analysis of variance [ANOVA] with three groups with effect size 0.30. For an effect size of 0.3, the sample size calculated was 22.6. We therefore enrolled 25 patients in each group, which was also feasible in our set up. This was also similar to total sample size for repeated measure which was 76. It was obvious also from previous studies that as visual analogue scale (VAS) scores had reduced rapidly from higher pain to no pain at all in most studies, a large measurable effect was expected which requires a small sample size.[6]

Data thus obtained was subjected to standard statistical analysis using Microsoft Office Excel 2007 and SPSS software version 22, IBM SPSS Statistics

base (SPSS South Asia Pvt., Ltd., Bengaluru, India) and the test of significance was one-way ANOVA for demographic data. Inter-group comparison of VAS score was done using Kruskal–Wallis – H-test, whereas comparison between two groups at a time was done by Mann–Whitney test. For comparison within the group, Friedman test was used. For comparison between the groups in vital and haemodynamic parameters one-way ANOVA, repeated measure ANOVA was used. The comparison between two groups was done using *post hoc* test for comparison between sleep, satisfaction and future repetition weighted Means were generated and compared with ANOVA.

RESULTS

There was no significant difference in the demographic profile, pre-operative VAS score and operative details among the three groups [Table 1 and Figure 1].

It was observed that in total 68 (90.66%) took the first dose of IV-PCA morphine within 30 min of starting their analgesic intervention and seven (9.33%) took the first dose between 30 min to 1 h [six (24%) from Group A and one (4%) from Group B] [Table 2].

When morphine consumption in all three groups was assessed at 8, 24 and 48 h, a statistically significant difference ($P = 0.001$) was seen between Group A and C and Group B and C, with morphine consumption highest in Group C compared to both A and B at all times. It was also observed that although morphine consumption was higher in Group B than Group A in all three instances, none were statistically significant on any of three instances and were ($P = 0.123$, 0.196 and 0.320) on 8, 24 and 48 h respectively.

Only four (5.3%) patients required additional rescue analgesic which was administered as a single dose of injection tramadol once during the 48 h period and all of them belonged to Group C. In the immediate post-operative period (time 0 h), the VAS score was significantly high in Group C (6.28 ± 1.83) as compared to Group A and B (3.54 ± 2.5) with ($P = 0.001$) and (4.36 ± 2.01) with ($P = 0.002$), respectively.

On comparing the pain relief provided by continuous wound irrigation to pain relief in continuous epidural group, it was seen that the mean pain scores were almost always less with continuous wound irrigation (CWI) but a statistical significance (P value ranges from 0.001 to 0.031) existed only in 60% of the readings in VAS at rest and VAS dynamic and 50% of the readings in PPS up to 24 h. Although mean pain scores were less in Group A compared to the Group B even in the period of 24–48 h but broadly no statistical significance was present between the groups during that period [Tables 3-5].

Patients in Group A also showed the highest satisfaction compared to Groups B and C expressed as mean (7.5 ± 0.76) and (6.3 ± 0.82 and 4.83 ± 0.663) respectively and was statistically significant ($P = 0.001$). When the quality of sleep was assessed it was also highest in Group A in comparison to other two which was (7.1 ± 0.846) and (6.33 ± 1.04, 6 ± 0.71) which was also statistically significant ($P = 0.001$).

In our study, the notable finding was that there was a statistically significant ($P = 0.001$) decrease in haemodynamic parameters within all the three groups over a period of 48 h. There were no neurological deficits attributable to pain therapy, motor status, sensory status in Group B. Out of the 75 patients,

Table 1: Demographic data, pre-operative visual analogue scale score, operative details

Demographic data, operative details, preoperative VAS	Group C (*n*=25)	Group A (*n*=25)	Group B (*n*=25)	*P*
Age (years), mean±SD	41.88±11.06	42.52±11.91	46.36±12.59	
Male:female	16:9	16:9	17:8	
ASA Grade I:II	20:5	20:5	20:5	
Weight (kg), mean±SD	62.96±11.00	60.10±7.58	60.56±10.49	
Height (cm), mean±SD	164±7.41	161±5.95	162±7.42	
Duration of surgery (mins), mean±SD	139.2±40.91	130.8±39.5	131.2±27.25	
Level of surgery				
L_1-L_2	1	0	0	
L_2-L_3	0	1	1	
L_3-L_4	1	17	4	
L_4-L_5	13	6	11	
L_5-S_1	10	6	9	
Incision length (cm)	4.36±0.79	4.36±0.93	4.1±0.72	0.43
Pre-operative VAS, mean±SD	6±1.70	6±1.68	6.1±1.64	0.97

VAS – Visual analogue scale; SD – Standard deviation; ASA – American Society of Anesthesiologists

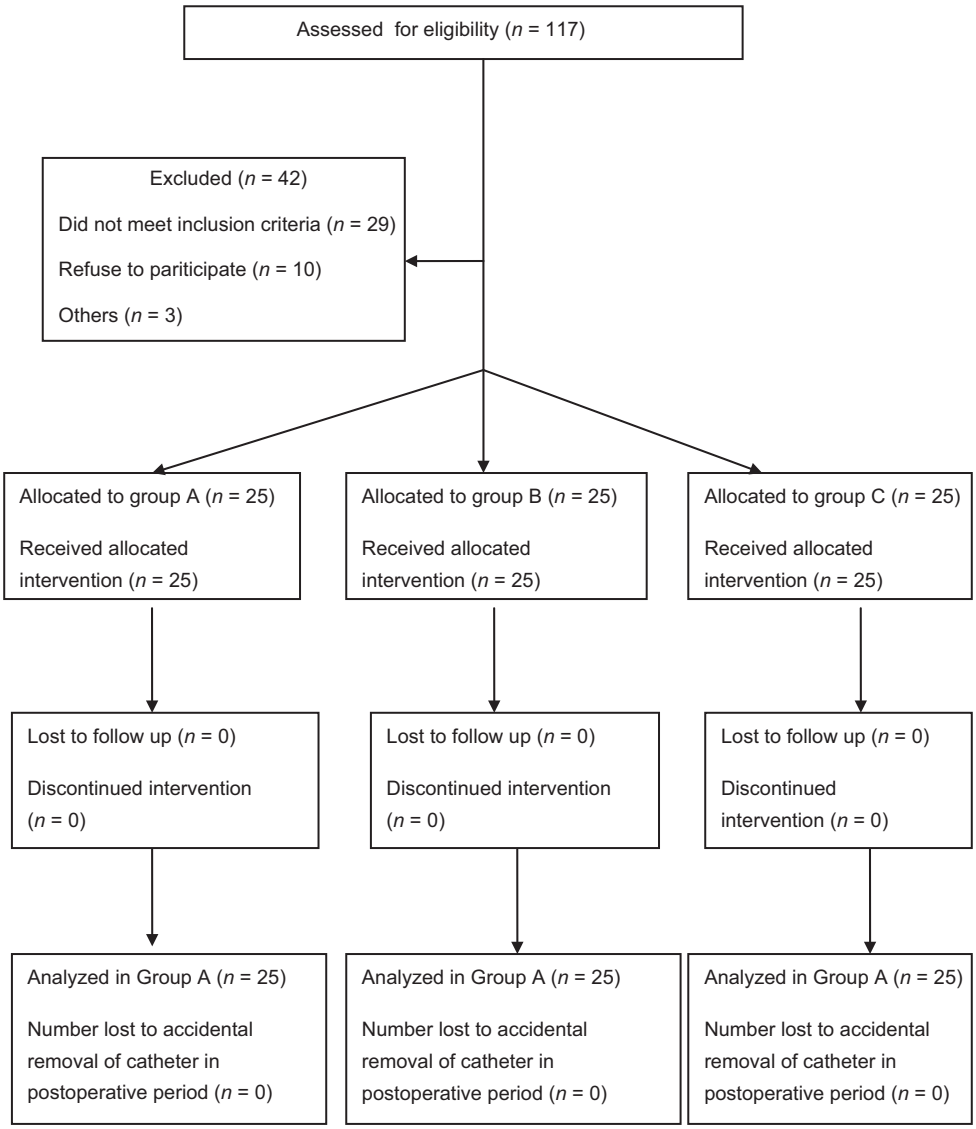

Figure 1: CONSORT flow diagram for patient eligibility

Table 2: Morphine consumption in mg (mean±standard deviation) in 8 h, 24 h and 48 h

Morphine consumption	Group C (*n*=25)	Group A (*n*=25)	Group B (*n*=25)	*P*
At 8 h	19.88±3.33	9.76±5.5	12.4±4.34	0.001*
At 24 h	31.8±6.72	14.24±8.56	18.12±6.52	0.001*
At 48 h	41.56±8.83	18±12.82	22.92±9.88	0.001*

P<0.05 significant, *P*<0.001 highly significant, *P*>0.05 not significant

16 patients had constipation of which four were in Group A, five in Group B and seven in Group C.

DISCUSSION

The expected findings in our study were that all three modalities gave good pain relief. The critical findings were that pain relief was better with continuous wound irrigation compared to continuous epidural analgesia; this is an important finding as most of us consider epidural as the epitome of pain control. This finding is in accordance to previous studies where mean pain scores with continuous wound irrigation technique were lower than other two groups.[7] Morphine consumption was also lower in CWI group compared to epidural group at all the three instances but without statistical significance, thus signifying better pain control.

The possible explanation for this observation can be attributed to a number of reasons. First local anaesthetics have prolonged anti-inflammatory effects based on prostaglandins antagonism, lysosomal enzyme release and possible inhibition of leukocyte migration.[9] Inflammation plays a major role in the evolution of symptoms. The nucleus pulposes contains

materials that are inflammatory and neuroexcitatory. The nerve roots do not become sensitised to pain signals until the inflammatory process is generated. Once the inflammation is established, however, the nerve root becomes exquisitely sensitive to pressure, producing pain with even gentle pressure. Second, long-lasting analgesic effect of local anaesthetic infusion and instillation can be attributed to the blockade of peripheral nociceptors that may reduce sensitisation at the spinal horns, and slower absorption from skin layers may further contribute to the long lasting effect. Local anaesthetics also cause increased wound perfusion and oxygenation enhancing wound healing. Other explanation is that epidural space was surgically invaded, and even after closure, there may be altered distribution of local anaesthetic in the epidural space, thus affecting the analgesic effect of the technique.[8-10]

Table 3: Visual analogue scale score (mean±standard deviation) among different groups at different time interval

Time	VAS	Group C (*n*=25)	Group A (*n*=25)	Group B (*n*=25)	*P*
0 h	Static	6.28±1.83	3.54±2.50	4.36±2.01	0.001*
0.5 h	Static	4.92±1.49	2.28±1.80	3.04±1.79	0.001*
1 h	Static	3.28±1.47	1.22±1.19	2.48±1.26	0.001*
2 h	Static	2.3±1.02	0.92±1.07	2±1.22	0.001*
4 h	Static	2.08±1.14	0.6±0.70	1.76±1.05	0.001*
8 h	Static	3.02±2.01	1.86±1.43	2.04±1.09	0.071
	Dynamic	3.8±1.84	2.2±1.34	2.44±1.66	0.02*
12 h	Static	2.46±1.18	0.98±0.96	1.92±1.07	0.001*
	Dynamic	2.88±1.66	1.44±1.08	2.48±1.63	0.02*
24 h	Static	1.64±1.22	1.02±1.29	1.56±1.04	0.031*
	Dynamic	1.8±1.29	1.46±1.65	1.98±1.27	0.104
36 h	Static	1.18±0.65	0.66±0.68	1.2±0.64	0.008*
	Dynamic	1.32±0.85	1.04±0.97	1.4±0.86	0.230
48 h	Static	1.02±0.54	0.54±0.81	1.12±0.72	0.007*
	Dynamic	1.16±0.55	0.84±0.85	1.36±0.86	0.091
P	Static	0.001*	0.001*	0.001*	
P	Dynamic	0.001*	0.001*	0.001*	

VAS – Visual analogue scale. *P*<0.05 significant, *P*<0.001 highly significant, *P*>0.05 not significant

Table 4: Post-operative pain scores (mean±standard deviation) of different groups at different time intervals

Time	Group C (*n*=25)	Group A (*n*=25)	Group B (*n*=25)	*P*#
0	2.72±0.54	1.36±0.7	2.04±0.84	0.001*
0.5	2.36±0.56	1.12±0.66	1.6±0.91	0.001*
1 h	2±0.57	0.76±0.52	1.48±0.71	0.001*
2 h	1.84±0.62	0.68±0.47	1.2±0.57	0.001*
4 h	1.68±0.62	0.68±0.55	1.16±0.55	0.001*
8 h	1.68±0.80	1.04±0.35	1.24±0.59	0.002*
12 h	1.64±0.81	0.84±0.37	1.16±0.68	0.001*
24 h	1.44±0.82	0.84±0.47	1.04±0.67	0.011*
36 h	1.12±0.52	0.72±0.45	0.96±0.45	0.019*
48 h	1±0.5	0.64±0.48	0.92±0.49	0.034*

**P*<0.05 significant, *P*<0.001 highly significant, *P*>0.05 not significant

In other studies comparing CWI with epidural analgesia, contrasting results were seen. In one study, it was observed that there was superior pain control with epidural infusion as compared to ON-Q infiltrating catheter in patients undergoing hepatic resection. The reason for difference could be that subjects in their study were given large bilateral subcostal incisions while in the present study incision were comparatively small.[11] Also subjects were administered levobupivacaine which has a slightly greater potency compared to ropivacaine.[12]

When pain relief was compared between continuous wound irrigation and IV PCA group, the CWI group was always found to be superior in pain control with lesser VAS scores and reduced morphine consumption in CWI group. This is similar to multiple studies comparing the two modalities in multiple spectrum of surgeries in which pain control with CWI was found to be superior to IV PCA.[5,13,14]

In our study, we observed comparable VAS values between epidural and IV PCA. The possible explanation could be the difference in the types of surgeries performed. There are ever-present efforts from the surgeon for decreasing incision size and minimal tissue injury especially in microdiscectomy. There is also a consideration that the epidural space is interrupted in this surgery thus making the spread of local anaesthetic unpredictable.

Studies showing results similar to our study compared the efficacy of post-operative continuous epidural analgesia versus PCA in patients undergoing lumbar fusion or thoracoscopy. Their results showed no

Table 5: Distribution of patients according to bowel recovery, quality of sleep, patient satisfaction and readiness for repetition of techniques in future

Parameters	Group C (*n*=25)	Group A (*n*=25)	Group B (*n*=25)	*P*
Bowel recovery (mean±SD)	60.04±12.85	52.27±10.77	47.56±13.44	0.002
Patient satisfaction 0:1:2:3	3:17:4:1	0:10:10:5	2:119:3	
Quality of sleep 0:1:2:3	2:11:11:1	3:4:15:3	4:10:5:6	
Repetition of techniques in future 0:1:2	3:14:8	0:8:17	2:12:11	

SD – Standard deviation

significant difference between the groups with reference to diet, ambulation and VAS scores which could be attributed to technical limitations namely, the low dose of bupivacaine and placement of the epidural catheter tip which may have prevented delivery of the drug to adequate segment.[15,16]

The sleep quality assessment in the first post-operative night showed a tendency to greater satisfaction in Group A, and it was statistically significant. Patients in CWI group were the most satisfied which is in accordance with a previous study.[7]

It was observed that most 17 (68%) patients in Group A were ready for future repetition of the modality of treatment provided to them in other future surgeries they might undergo. Whether CWI may increase wound infection has been controversial issue. There was no wound infection or wound healing complication in any of the patients in the study. Furthermore, there were no complications related to placement or removal of catheters.

CWI can especially be useful in a place where availability of opioids is limited or not present and where rigorous post-operative monitoring is not present.

Only four (5.3%) patients required additional rescue analgesic, all of them belonged to Group C. The difference could be because in Group A and B after the patient was made supine, bolus of 0.25% levobupivacaine was given or infusion was started at 5 mL/h.

The limitation of the present study was of a single-blinded design. Patients were preoperatively explained in detail about various postoperative pain control techniques they might encounter and an informed consent was taken. It was neither practical nor safe for medical and nursing staff responsible for patient care to be blinded to randomisation, although every effort was made to maintain single blinding by avoiding discussion of analgesic techniques within earshot of patients, to avoid patient bias while answering questions of future repetition of the technique.

No prior study till now has compared the three modalities in patients undergoing microdiscectomy. Future research should include long-term follow-up of patients, to assess effects on neuroplasticity and chronic pain modulation.

CONCLUSION

Continuous wound irrigation/instillation is an effective post-operative pain control technique after microdiscectomy, and is superior to epidural analgesia and intravenous patient controlled analgesia. It is associated with haemodynamic stability and minimal side effects.

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Conflicts of interest

There are no conflicts of interest.

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