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Original Article

Comparison of Locking Plate and Percutaneous K-wire in Treatment of Proximal Humerus Fractures

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Abstract

Background and Objectives: **The most effective method for the surgical treatment of proximal humerus fractures has not been established. Two commonly used techniques are locking plate and percutaneous K-wire. We performed a retrospective study to compare these two treatment strategies.**

Materials and Methods: **A total of 62 patients were selected for review. Each patient was treated by one of the two methods. Data including operative time, blood loss, pain scale, neck-shaft angle, shoulder score, and operative complications were collected.**

Results: **Thirty patients were treated with locking plate fixation, and the rest were treated with percutaneous K- wire fixation. Percutaneous K-wire group was associated with significantly shorter operative time and length of hospital stay, lesser blood loss and lower postoperative pain ($P < 0.05$), but had more complications ($P = 0.046$). There were no significant differences in shoulder score and neck-shaft angle between the two groups.**

Conclusion: **Percutaneous K-wire technique is similar in effectiveness to the locking plate in the treatment of proximal humerus fractures with a shorter operative time and hospital stay, lesser blood loss and lower postoperative pain, but had more complications**

Keywords: **K-wire fixation, plate fixation, proximal humerus fractures**

Introduction

Proximal humerus fractures are on the rise due to road traffic accidents and increase in the incidence of osteoporosis. They constitute about 4-5% of all fractures[1]. Minimally displaced fractures, regardless of the number of fracture lines, can be treated with closed reduction but displaced fractures require anatomical reduction with internal fixation[2,3].

Several treatment modalities have been proposed, depending upon the fracture pattern, patients' age and level of activity, and associated medical co-morbidities: conservative treatment[4], open reduction and internal fixation (ORIF)[5], joint replacement[6,7] and percutaneous fixation[7,8]. Good clinical results were obtained in 92% of cases treated with ORIF, 87% for cases treated with conservative treatment and 87.5% of cases treated with shoulder arthroplasty[6,7]. Open reduction and internal fixation (ORIF) has the advantages of anatomical reduction and early mobilization. It may however be associated with higher rates of infection, damage to arteries and nerves, reduction loss, implant failure, nonunion or malunion,

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impingement, and osteonecrosis of the humeral head[9,10]. If adequate reduction is not achieved or medial buttress is not sufficient, reduction loss and subsequent fixation failure are possible, especially in osteoporotic elderly patients[11].

Conservative treatment with closed reduction and percutaneous pinning has limited indications, less blood loss, lower risk of neurovascular complications and less interference with glenohumeral joint motion. This technique, however may not ensure anatomical reduction and early mobilization. It is also associated with pin tract infection and a long recovery period[12]. The purpose of this study was to retrospectively compare between the two techniques in terms of clinical outcomes. Also, the functional recovery and operative complication were examined in details.

Materials and Methods

A retrospectively review was conducted between 2007 and 2014, 62 patients with proximal humerus fractures were surgically treated at the Sawangdandin Crown Prince Hospital. Inclusion criteria for this study were: (a) patients with 2, 3 or 4 parts of fractures, (b) acute and unilateral fracture, (c) internal fixation with either a locking plate or percutaneous K-wire fixation, and (d) normal shoulder function before injury. Exclusion criteria included: (a) pathological fractures, (b) primary or metastatic bone tumors, (c) major neurological deficits, (d) open fractures, (e) other injuries to the same upper limb requiring surgery, (f) fracture dislocation, and (g) any medical condition that excludes surgical treatment.

The locking plate used in this study is Proximal Humeral Internal Locking System (titanium; thickness: 4.2 mm; width: 12 mm; length: 105-231 mm; Synthes) which was anatomically pre-contoured with 3 to 10 holes on the plate shaft and 9 holes for head screws. The proximal suture holes were applied to secure the tuberosity fragments and the plate.

Operative techniques for each group were as follows: Locking plate group patients with proximal humerus fractures were treated with open reduction and internal fixation (ORIF) with locking plate. Surgery was performed under general anesthesia, patient in supine position with a small sand bag under the shoulder. All patients received prophylactic dose of intravenous antibiotic preoperatively. The fracture was exposed through a delto-pectoral approach and fracture fragments were reduced. The reduced fragments were held in position with K-wires under guidance of image intensifier. Definitive fixation with locking plate was done with the plate positioned lateral to the bicipital groove, sparing the tendon of long head of biceps. The plate was placed at least 1 cm distal to the upper end of greater tubercle. The required lengths of the locking screws were determined with a direct measuring device over the K-wire, and at least 6 locking screws were inserted in the humeral head. Lesser tuberosity was fixed with separate screws or wires if found to be avulsed. If the fracture site had a

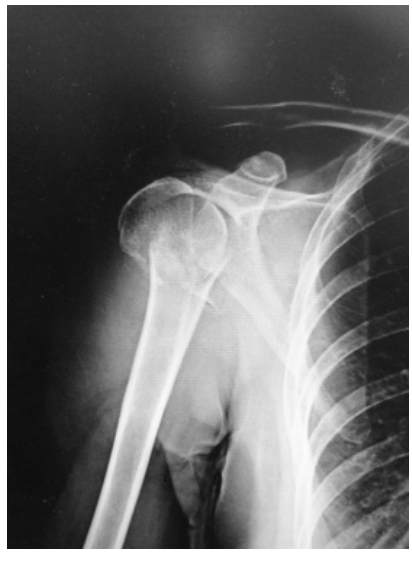

Figure 1 Radiograph of a proximal humerus fracture of a 52-year-old woman

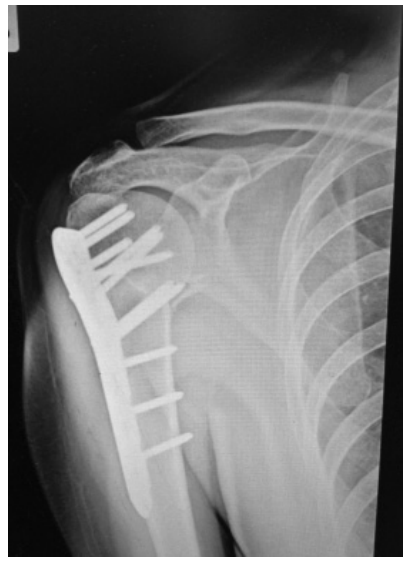

Figure 2 Radiographs 2 weeks after the surgery

bone gap, an iliac bone graft was inserted. Range of motion of shoulder and impingement were checked on the table. Wound was closed in layers with suction drain (Figure 1, 2). Active range of motion (ROM) exercises were initiated on the first postoperative day. Sutures were removed after 10 days. Follow up was at one week, then every month for 6 months, and then at 12 months for final evaluation.

In percutaneous K-wire fixation group, surgery was performed under general anesthesia with the patient in supine position. Near anatomical reduction was achieved by manual traction and arm mobilization. K-wires under image intensifier were inserted depending on the number of fracture fragments. For difficult reduction, one K-wire was used as a joystick. Care was taken on the orientation and pin placement to avoid injury to the axillary nerve, the radial nerve and the anterior circumflex humeral vessels lying medially. K-wires were left out of skin and bent at the extremity to control migration. If the fracture site had a bone gap, an iliac bone graft was inserted. (Figure 3, 4). Patients were encouraged to start active mobilization of wrist and elbow on the first postoperative day. Dressing of the pin tracts were done on alternate days. Postoperative care was as for open reduction and internal fixation (ORIF) with locking plate technique.

Standard antero-posterior and axillary view radiographs were obtained and evaluated for fracture healing, non-union, malunion, loosening of implant, loss of reduction and avascular necrosis of head of humerus. The criteria for radiographic healing was when all fragments showed substantial cortical continuity. The neck-shaft angle was formed by the first line drawn from the superior border to inferior border of the articular surface. The second line was then drawn perpendicular to the first and through the center of the humeral head. The angle created by this line and the line bisecting the humeral shaft were measured as the neck-shaft angle.

The data recorded for all patients included operative time, blood loss, visual analogue pain scale (0, none to 10, severe) on the first post-operative day and operative complications. At the follow-up in 6 months, shoulder scoring system of Constant and Murley[13] was applied. In this system, both subjective and objective clinical data were included, with a maximum score of 100 points. Pain (15 points), activities of daily living (20 points), range of motion of the shoulders (40 points), and muscle power (25 points) were evaluated. The Student's t-test, chi-square test, and Fisher's exact test were used in the comparison of outcomes between the two groups. Two-sided *p*-values less than 0.05 were considered statistically significant.

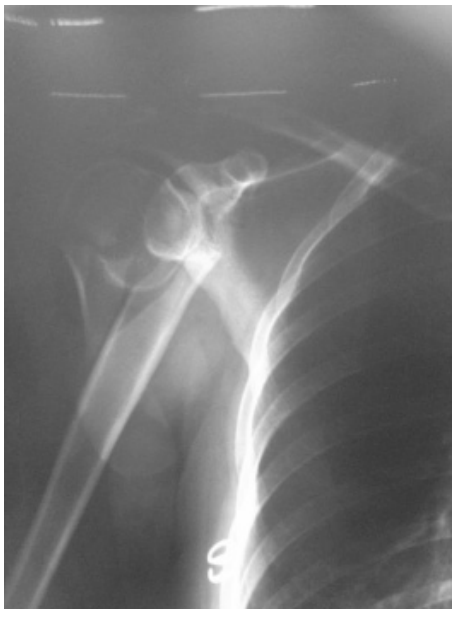

Figure 3 Radiograph of a proximal humerus fracture of a-46-year old women

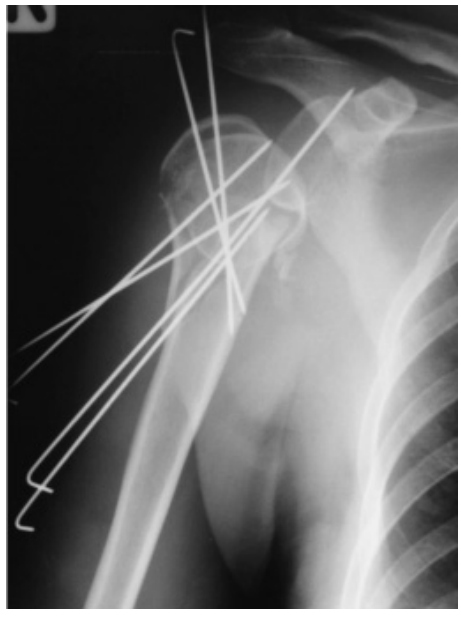

Figure 4 Radiograph 2 weeks after the surgery

Results

There were 62 patients in the present study, with an average age of 46.7 years (range 16- 68 years). All were followed up for more than six months after discharge from the hospital. The average follow-up was 12.7 months (range 6- 24 months). The patients were divided into two groups, based on the method of treatment. The locking plate group included 30 patients and the percutaneous K-wire group included 32 patients. Length of hospital stay was 5.6 days (range 4-7 days) for the locking plate group and 3.6 days (range 3-4 days) for the percutaneous K-wire ; this difference was significant (p<0.01). The mechanisms of injury and demographics data related to each group were shown in Table 1.

Both groups were similar in fracture patterns on Neer classification. The difference between in the two groups was not significant (p=0.590). Table 2 summarized characteristic of fracture.

Mean operative time was 112 minutes (range, 89-141 minutes) for the locking plate group and 52 minutes (range, 41- 68 minutes) for the percutaneous K-wire group; this difference was significant. Average blood loss during surgery was 212 ml (range, 100-300 ml) for the locking plate group and 34 ml (range, 10-50 ml) for the percutaneous K-wire group; this difference was significant. Average pain score on the first post-operative day was 4.8 for the locking plate group and 2.3 for the percutaneous K-wire group; this difference was significant. Details of outcomes were given in Table 3.

At 6 months follow-up of the locking plate group, mean score for the affected shoulder using the scoring system of Constant and Murley was 86.3 points, and mean score for the contralateral shoulder was 94.2 points. In the percutaneous K-wire group, mean score

Table 1 The injury mechanism, length of hospital stay, preoperative demographics for both treatment groups

Characteristics	Locking plate (n=30)	SD	Percutaneous K-wire (n=32)	SD	*p*-value
Gender (M/F)	16/14		18/14		0.818
Age (years): mean(SD)	45.6	4.3	48.3	5.1	0.792
Follow-up (months) : mean(SD)	12.7	5.6	12.8	6.2	0.922
Vehicular trauma: number (%)	16(53.3%)		19(59.3%)		0.632
Injury time (days) :mean(SD)	1.4	0.3	1.6	0.4	0.685
Length of hospital stay: mean(SD)	5.6	0.5	3.6	0.4	<0.01

Table 2 Characteristic of fractures

Fracture type	Locking plate	Percutaneous K-wire
2-part	14	17
3-part	12	9
4-part	4	6
Total	**30**	**32**

Table 3 Comparison of outcome between the two treatment groups

Outcome	Locking plate (n=30)	SD	Percutaneous K-wire (n=32)	SD	*p*-value
Operative time (min)	112 (range, 89-141)	13	52 (range, 41-68)	7	<0.01
Blood loss (ml)	212(range, 100-300 ml)	48	34 ml (range, 10-50ml).	9	<0.01
Pain scale	4.8 (range, 2-8)	1.4	2.3 (range, 1-4)	0.6	<0.01

Table 4 Comparison of shoulder scores and neck-shaft angle between the two groups

	Locking plate	SD	Percutaneous K-wire	SD	*p*-value
Affected shoulder	86.3 points (71-100)	7.8	82.3 points (68-100)	8.2	0.312
Contralateral shoulder	94.2 points (86-100)	3.2	93.6 points (84-100)	3.8	0.532
Neck-shaft angle (degrees)	126 (120-132)	3	128 (120-136)	4	0.914

for the affected shoulder was 82.3 points, and for the contralateral shoulder was 93.6 points. There was no significant differences in the scores between the two groups. The scores varied depending upon the fracture type with the worst in four-part fractures.

The neck-shaft angle measured on radiographs at healing was 126° in the locking plate group and 128° in the percutaneous k-wire group. The difference between neck-shaft angles in the two groups was not significant (p=0.914) (Table 4).

Post-operative complications were noted in 6 patients in the locking plate group and in 14 patients in the percutaneous K-wire group. In the locking plate group, one patient had non-union (four-part fracture), two patients had infection (one patient with two-part fracture and one patient with three-part fracture) and one had avascular necrosis of the humeral head (four-part fracture). For the patients with nonunion, bone grafting with removal of the previous implant was performed. The patients with infection were treated with intravenous antibiotics after obtaining culture sensitivity reports. One patient with avascular necrosis of the head of humerus refused arthroplasty. In the percutaneous K-wire group, three patients had pin tract infection (one patient with two-part fracture and two patients with three-part fracture), one patient had non-union (three-part fracture), three patients had malunion (one patients with two-part fracture and two patients with three-part fracture), three patients had K-wire loosening (one patient with three-part fracture and two patients with four-part fracture), and four patients had loss of reduction (two patients with three-part fracture and two patients with four-part fracture), The patients with pin tract infection were treated with daily dressings and antibiotics.Those with non-union were treated with ORIF and bone grafting. The patients with K-wire loosening underwent K-wire replacement.

Table 5 Comparison of complication in both groups

	Locking plate	Percutaneous K-wire
Non union	1	1
Infection	2	3
Malunion	2	3
Avascular necrosis of humeral head	1	0
Implant loosening	0	3
Loss of reduction	0	4
Total	**6**	**14**

This difference was significant (p=0.046) (Table 5).

Discussion

Proximal humerus fracture is the most common fracture of the shoulder. It is the second most common site of fracture in the upper limb after distal radius. These fractures have been treated with a wide range of options, namely, non-operative, ORIF, percutaneous screw/pin fixation and external fixation. Fractures of this region are common with both high-energy injuries in people of all ages, as well as simple falls in older people with osteoporosis. In elderly patients, fragility of the bone complicates the pattern of fracture. These patients also have comorbidities which makes treating them even more challenging. Zyto and colleagues reported mean constant score of 65 points and no complications with conservative treatment compared with surgical approach, resulting in mean value of 60 points and with complications (avascular necrosis, infection)[4]. Magovern, Kenner, and Nho found good constant scores with surgery and relatively few complications, with better functional scores for percutaneous fixation[8,14,15]. Percutaneous fixation has limitations of poor reduction of fracture fragments,

pin tract infection and long period of recovery[8,15]. But it has the advantages of less soft tissue stripping with less exposure, less blood loss and minimal invasiveness. In cases where there is loss of reduction due to pin loosening, ORIF can be performed[15]. ORIF with PHILOS plate for treatment of proximal humerus fractures has the advantages of accurate reduction, early mobilization, better fixation in osteoporotic bones and ease of reconstruction of comminuted irreducible fractures. On the other hand, it has the disadvantages of excessive soft tissue dissection and blood loss, risks of injury to the neurovascular structures and increased risk of avascular necrosis of humeral head[16,17]. However, recent studies have shown good long term results of proximal humerus fractures managed by the PHILOS plate[18,19].

We believe that age and osteoporosis are the main reasons for the failure of the pins to hold the reduction. Other authors have described a combination of pins with other forms of internal fixation, such as screws, to overcome this problem[20]. Recently we have added two additional antegrade pins from the greater tuberosity into the medial cortex in order to improve stability. These pins are left outside the skin, and could increase the rate of infection.

Varus mal-reduction is a complication reported in both types of fixation. Agudelo et al.[12] found that among 73 patients treated with a locking plate, 30.4 % of those with a neck-shaft angle less than 120˚ developed loss of fixation as compared to only 11 % in patients with a postoperative neck-shaft angle greater than 120˚. This suggests that varus malreduction is a risk factor for loss of fixation and should be carefully assessed during surgery. Our study demonstrated that both locking plate and percutaneous K-wire fixation methods yielded no significant difference in postoperative neck-shaft angle with 126˚ and 128˚ in the locking plate and percutaneous K-wire group, respectively (p=0.914). Both treatments resulted in neck-shaft angles that were at or greater than 120˚, which proved that varus malreduction can be avoided and is not attributed to the type of implant used.

The maintenance of neck-shaft angle and restoration of medial support are important in achieving an adequate reduction. The degree of humeral head angulation has a substantial effect on the final clinical outcomes. Malreduction of the humeral head is the most common technical error in plate fixation. Patients with a poor reduction had greater than 20˚ of varus malreduction, which resulted in the mechanical loss of fixation and poor subsequent clinical outcomes.

Care should be taken to prevent axillary nerve injury[21]. Gardner et al.[22], through a cadaveric study, reported that the axillary nerve was located 6.3 ± 0.5 cm below acromion. Smith et al.[23] reported that the safe zone of the PHILOS plate for proximal screw insertion consisted of the six most proximal holes only. They emphasized the necessity of gentle palpation and digital protection of the nerve during proximal plate and screw insertion. Nonetheless, routine identification of the axillary nerve to avoid traction injury is not recommended. Six patients were suspected of having an axillary nerve injury as they had difficulty elevating in forward flexion and lateral elevation. One patient was diagnosed with axonotmesis.

The common complication found in locking plate fixation was primary screw perforation, resulting from incorrect surgical technique and fracture compression[24-25]. Skill and comfort of the surgeon play a significant factor in the decision to use one method of fixation over the other. In a study conducted by Fazal et al. it was seen that PHILOS plate fixation provided stable fixation with minimal implant problems and enabled early range of motion exercises to achieve acceptable functional results[26].

This study had a few limitations: (a) it was a retrospective study and not randomized, so there was selection bias; and (b) the size of the study was relatively small, thus a few comparisons lacked statistical power. Finally, the follow-up period of one year may be too short to draw final conclusions on long-term outcome and complications such as avascular necrosis of the humeral head.

Conclusion

Both locking plate and percutaneous K-wire for treatment of proximal humerus fractures could achieve good results. However, percutaneous K-wire fixation had more advantages, such as shorter operative time and hospital stay, lesser blood loss and lower postoperative pain, but had more complications than locking plate fixation.

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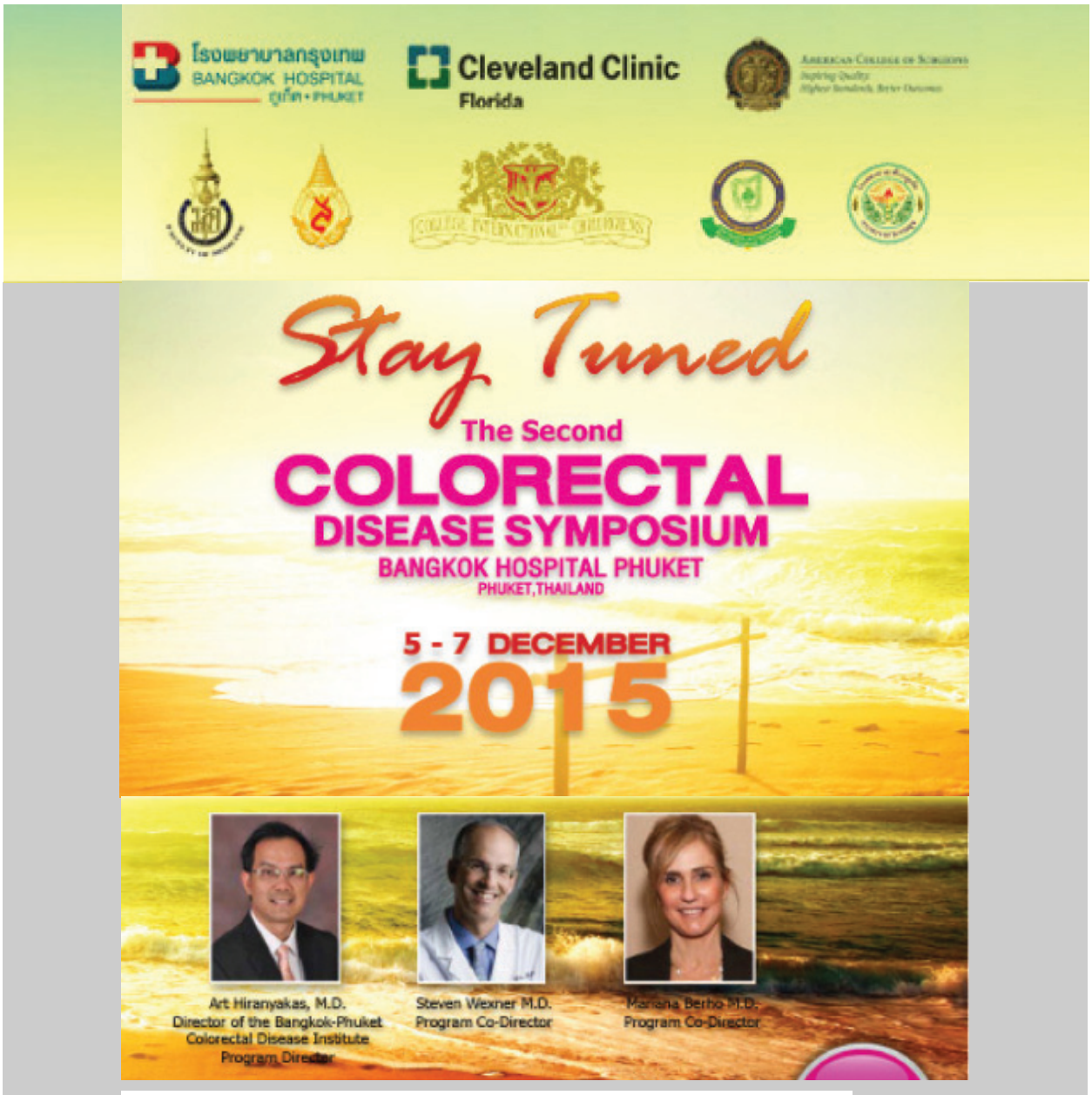

Highlights

- Multidisciplinary approach to colorectal cancer
- Advanced therapeutic colonoscopy
- Colorectal imaging
- Colorectal histopathology
- Minimal access colorectal surgery including robotics and laparoscopy
- NOTES and trans-anal access surgery
- Colorectal genetics and molecular biology
- Controversies in the management of rectal prolapse
- Advanced surgical management of fecal incontinence and constipation
- Debates in the treatment of hemorrhoids
- New options for the management of fistulas

Topics

- Live Surgery
- Live Specimen Assessment for Rectal Cancer Specimen
- Multidisciplinary Approach in Rectal Cancer Management
- Benign Colorectal Conditions
- Functional Colorectal Disorders
- LIFT Workshop