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Cemented Total Hip Arthroplasty In Dogs

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Abstract: *Total hip arthroplasty (THA) is an excellent salvage procedure for debilitating conditions that included osteoarthritis, hip luxation, femoral head and neck fracture and revision of femoral head ostectomy providing excellent hip joint function. Six dogs with clinical condition of hip dysplasia with luxation (three), severe osteoarthritis (two) and hip luxation (one) weighing 30 kg b.wt were subjected for THA. The animals were premedicated with glycopyrrolate @ 0.002 mg/kg body weight and 20 minutes later xylazine hydrochloride @ 1 mg/kg body weight i/m and anesthesia was induced with propofol @ 5 mg / kg b.wt i/v and maintained under isoflurane anaesthesia. The animals were preoxygenated 20 minutes prior to surgery with particular considering bone cement implantation syndrome. THA was performed through craniolateral approach of thigh. Indigenously designed stainless steel 316 L modular hip prosthesis to suit the canine femur of four different sizes viz. size- 5 -9, with the head sizes of +0 or +3 and the acetabular cup made of UHMWPE in the size ranged from 20 to 25 mm outer diameter with radio opaque wire for defining the lateral angle of the cup was used. The implants were selected based on the preoperative template measurement with the ventro-dorsal hip radiographs. PMMA bone cement was used for fixation of implants. Postoperative orthopaedic clinical and radiological assessment was made by numerical scoring system modeled on* ***WOMAC scoring index.*** *Radiographic assessment scores was performed as per Iwata et al.(2008) by standard hip extended radiograph, that included the mean score of canal fill was 1.17 ± 0.48, cement mental fill was 1.00±0.37, presence of radiolucent line in and around the acetabular component was 0.83 ± 0.48, cement porosity was 0.83 ± 0.54 and position of cup was 1.17 ± 0.31. On clinical assessment scores, the mean score of pain on palpation were 2.33 ± 0.56, early complication was 1.83±0.75 and late complication was 1.83± 0.70. The mean score of radiological and clinical assessment was 13.50± 4.67 out of 40 points. The out come of procedure was assessed excellent in three cases, good in one case and poor in two cases. The dogs exhibited signs of pain free limb movement, full range of motion of the limb with increase in thigh muscle mass with no limb shortening except in two cases where implant luxation was noticed for which the implant was removed and made to form pseudoarthrosis.*

Key words: *Coxofemoral Joint diseases - dogs- Total hip arthroplasty- excision Arthroplasty dogs- Total hip replacement- Hip joint affections.*

I. Introduction

Coxofemoral joint diseases are the most common affections encounter in dogs; approximately 20 per cent of the dog populations are affected necessitating newer approaches in the treatment protocols to satisfy the ethical and welfare concerns. The conditions associated with coxofemoral joint includes fracture of acetabulum, luxation of hip, capital femoral physeal fracture, fracture of femoral head and neck, hip dysplasia or

Legg-Calve-Perth's disease and degenerative changes which prevents stabilization of the hip and osteoarthritis. The etiology might be of non inflammatory disease conditions which included degenerative joint disease and osteoarthritis, characterized by degeneration of the articular cartilage, hypertrophy of the bone margin and changes in the synovial membrane which might be of primary due to ageing or secondary due to developmental diseases. Luxation or fracture might occur due to trauma and neoplasia. Inflammatory conditions included infectious cause's i.e. septic arthritis secondary to systemic infection and non-infectious cause i.e. hip dysplasia (Brinker *et al.*, 1990 and Denny and Butterworth, 2000). When the response to the conservative management fails surgical treatment should be opted (Schulz and Dejardin, 2003). Various surgical options are available for the coxofemoral disease depending on the age, nature of disease and surgeons expertise. Salvage procedure for coxofemoral joint diseases includes excision arthroplasty and total hip arthroplasty (THA). Total hip arthroplasty has been proposed as an alternative to excision arthroplasty for treatment of coxofemoral joint disease in dogs. In THA, the prosthesis is fixed into femoral canal and acetabulum after performing femoral head and neck excision through cranio lateral approach. The surgical outcome was excellent with the animal gaining 95 per cent of functional ability (Olmstead *et al.*, 1983; Parker *et al.*, 1984 and Hulse and Johnson, 2007).

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II. Material And Methods

Six dogs diagnosed clinically, orthopaedic and radiographic investigation with coxofemoral joint affections which didn't responded to medical managed were subjected to Total hip arthroplasty (THA). The average age of dogs was 4 years with body weight of 30 kg. The disease conditions included were hip dysplasia with luxation in three cases and one each of osteoarthritis and hip luxation. Preoperatively, the common clinical signs included pain, varied degrees of lameness, gait and postural abnormality with crepitation, increased laxity 'Ortolani signs' and limb shortening ***(Table 1).***

Anesthetic protocol included premedication with inj. tramadol @ 0.2 mg/kg body weight, prior to inj. glycopyrrolate @ 0.002 mg/kg body weight and 20 minutes later inj. xylazine hydrochloride @ 1 mg/kg body weight i/m with inj. propofol induction @ 5 mg / kg b.wt i/v and maintained with isoflurane anaesthesia under IPPV. The animals were preoxygenated 20 minutes prior to surgery and anaesthesia considering Bone cement implantation syndrome (BCIS). The femoral stem was indigenously designed made up of 316 L medical grade stainless steel to suit the canine femur with round edges, blunt tip and laterally slightly flattened with grooves to provide support for cement mantle with an neck angle of 135^0 (Fig. 1). The femoral stems used in this study were size-6 for four cases, size-7 for one case and size-9 for one case. The head diameters were 14 mm, 20 mm and 17 mm (OD) and head size was +3 for all the femur stems. Acetabular cup made from ultra high molecular weight polyethylene (UHMWPE) used in this study ranged from 20 to 25 mm outer diameter with radio opaque wire for defining the lateral angle of the cup. The 14 mm head for 20 mm (OD) acetabular cup and 17 mm (OD) head fit to acetabular cups of 22 and 24 mm (OD) ***(Table II)***. The bone cement used in this study was polymethyl methacrylate (PMMA) bone cement (Simplex $^@$ Howmedica- Osteonics) of 20 g (Half dose) and 40 g (Full dose) depending on the requirement.

The standard plastic templates for THA was used for the selection of implant size preoperatively by super imposing the images obtained from the radiographs available and intra operatively the implants were also selected by fitment of the implant by trial insertion before fixing with cement (Olmstead, 1995 and Nelson *et al.*, 2007). THA was performed through cranio lateral approach. After femoral head and neck osteotomy the femoral canal was reamed and rasped and the tissue debris were removed from the femoral canal by pulsative lavage with normal saline by syringe attached to tubing and packed with sterile gauze. The acetabulum was reamed with acetabular reamer to remove the remnants of tissues and to convert the acetabulum into hemisphere for the exact placement of the acetabular cup. Final reaming was made with finer acetabular reamer and was directed in such a way to achieve 20 to 30^0 of anteversion. Three to four anchoring holes for keying of the PMMA to the acetabulum over the dorsal rim of acetabulum were made using drill bit of appropriate size. The acetabular cup was fixed by using acetabular cup positioner in 20 to 30^0 of anteversion. The stem was inserted in normoversion or slight retroversion to prevent luxation and improper wear on tear on the head and acetabular component. The femur was checked for fitment, luxation by flexion, extension and rotation. Excess cement adhering to the acetabular cup or to the femoral neck was removed with rongers or bone nippers. The site was completely flushed with normal saline and antibiotic solution with lignocaine (2 %) was sprayed over the site (Fig.2). The joint capsule was closed with PGA 1-0 by simple interrupted fashion. The muscle, subcutis and skin were closed as per standard methods as mentioned earlier.

Postoperative orthopaedic clinical and radiological assessment for the dogs that underwent total hip arthroplasty was made by numerical scoring system modeled on **Western Ontario and McMaster University Osteoarthritis scoring Index (WOMAC score)** where in five point numerical score (from 0 to 4) was given for each question with lower score better outcome than higher score with a possible score of 40 points (Iwata *et al.*, 2008). The WOMAC osteoarthritis index scoring included canal fill, cement mantle over the stem and acetabular cup, presence of radiolucent line around the acetabular component, cement porosity, position of the stem and cup position. The possible score for radiological assessment totaled to 28 out of 40 points. Long term outcome was made on the operated animals for a period extending two months to twelve months by the way of owners assessment questionnaire with a possible score of 44 points as per WOMAC osteoarthritis scoring index (Iwata *et al.*, 2008).

III. Results And Discussion

The surgical option for the coxofemoral joint suggested by Rischer *et al.* (1985), Slocum and Slocum (1998), Denny and Butterworth (2000) and Hulse and Johnson (2007) included reconstructive procedure that included closed reduction with sling placement or open reduction with toggle fixation, transarticular pin, anchor sutures and capsular synthetic techniques for luxation. TPO and pubic symphysiodesis were performed for young dogs and Sertl shelf arthroplasty and femoral neck lengthening for hip dysplasia and K-wiring and lag screw fixation for femoral head and neck fractures. Salvage procedure for coxofemoral joint affections included femoral head excision and total hip replacement (Olmstead *et al.*, 1983; Parker *et al.*,1984; Vasseur, 1998; Dyce *et al.*,2000 and Iwata *et al.*,2008). Olmstead *et al.* (1983) suggested that for performing THA, the dogs should be about 10 to12 months to ensure that no further longitudinal femoral growth would occur and weight about 16 to 18 kg so as to accommodate the acetabular cup and there was no upper limit for age or weight. The weight of dogs ranged from 26 to 45 kilogram (Avg. 30 kg) and the age ranged from 8 months to 10 years (Avg. 4 years). Dyce *et al.* (2000)

reported that out of 285 dogs which underwent total hip replacement, the mean body weight was 38 kg (16-73 kg) and the mean age of the dogs was 3.9 years (7 months to 12 years).

Preoxygenation, tramadol-glycopyrrolate and propofol-isoflurane anesthetic regimen was found to be effective, adequate, and safe and no untoward symptoms were observed during the surgery. The dogs that subjected to THA were preoxygenated 20 minutes prior to surgery and anaesthesia was performed with particular attention to prevent hypovolaemia by adequate rehydration and increase of inspiratory O_2 tension prior to stem insertion. General anesthesia for THA should be conducted with particular attention to prevent hypovolumia by adequate rehydration and aggressive blood transfusion and increased inspiratory oxygen tension prior to stem insertion of stem (Otto and Matis, 1994). Craniolateral approach with partial deep gluteal tenotomy was found to be convenient and provided excellent visualization of the joint for performing femoral head and neck excision and placement of the hip prosthesis (Olmstead *et al.,* 1983 and Ota *et al.,* 2005). Schulz (2000) reported that the implants used for femoral head and stem were composed of stainless steel, cobalt chrome, or titanium and the acetabular cup was made of ultra high molecular weight polyethylene (UHMWPE) material used for total hip replacement. The head size used in this study was +3. Complication due to luxation because of smaller head size was noticed in two cases. 66 per cent of the cases responded well to the treatment. Olmstead (1995) used 14 mm to 17 mm (outer diameter) femoral heads which could be fitted on all five stems (#6 to #10 size). Dyce *et al.* (2000) observed that the most commonly used femoral stem and head size was #7 (37 %) and +6 (48%) on 285 dogs which underwent total hip replacement. The size of the acetabular cup used in this study ranged from 20 to 25 mm outer diameter with radio opaque wire for defining the lateral angle of the cup. The 14 mm head for 20 mm (OD) acetabular cup and 17 mm (OD) head fit to acetabular cups of 22 and 24 mm (OD). Ota *et al.* (2004) measured the hip morphology of German shepherd dogs with the mean age of 35.8± 18 months and body weight of 29.4± 4.93 kg by computed tomography and found that the mean acetabular width was 23.4 ±1.87 mm, depth 11.0 ± 1.35 mm, ventral rim distance 13.1±1.69 mm, dorsal acetabular rim distance 16.4± 2.25 mm and femoral head diameter 20.6 ± 1.33 mm (Olmstead, 1995).

The femoral neck cut was determined by the template radiograph film to the size of the femoral neck. Pulsative lavage with 0.95% of $NaCl_2$ was made to remove debris and clots and the bleeding was arrested by application of 3 per cent hydrogen peroxide and the canal was plugged with saline soaked gauze. Ota *et al.* (2005) reported that after femoral head osteotomy the femoral canal was prepared through standard reaming, broaching and filing and then pulsative lavage with normal saline (0.95% $NaCl_2$) followed by aspiration of fluid, blood or debris before cementing. Thorough reaming of the acetabulum should be made with power reamer to remove tissue debris and to make the acetabulum hemi spherical. Four to five anchoring holes are drilled over the dorsal acetabular rim for cement holding. After preparation, the acetabulum was packed with saline soaked gauze until cementing (Olmstead, 1995).

The bone cement was mixed by hand mixing (first generation technique). Ota *et al.* (2005) evaluated the effect of different cementing technique on radiographic cement mantle grade and short term aseptic loosening of the femoral component in 284 canine total hip replacements and reported that 2^{nd} and 3^{rd} generation cementing techniques resulted in better cement mantle but did not affect the incidence of short term aseptic loosening of femoral component. The acetablular cup was placed in an angle of lateral opening of 35 to 45^0 and slightly at 10 to 20^0 retroversion. The stem was inserted in normoversion or slight retroversion for preventing luxation. No complication due to stem insertion was noticed in this study. Excessive anteversion or retroversion of either femoral or acetabular components contributed to risk of luxation. Nelson *et al.* (2007) observed stem retroversion with and without cement subsidence and more subtle relative mal orientation of cup and stem component was a contributing factor for the dorsal and ventral luxation of the femoral head. The joint capsule was sutured which had provided implant stability post operatively. Cross *et al.* (2000) reported that in THA the implant stability was likely to be dependent on joint capsule closure integrity rather than acetabular position which might had led to implant luxation in the acute post operative period.

Dogs subjected to THA were kept under cage rest for two days and from third post operative day leash walk with support of abdomen belt for short distant was advised for first week. Cross *et al.* (2000) observed that in THA, luxation most likely occurred in the acute post operative period and hypothesized that the capsule and periarticular tissue had not yet formed. The dense fibrous cuff potentially prevented luxation and opined that the animal should be immobilized after surgery. The postoperative gait analysis four cases (66%) had varied degree of weight bearing and two cases (33%) showed partial weight bearing. Short stilted gait was exhibited by two cases (33%). All the animals gained near normal weight bearing in 48 weeks of post operative period except two where the lameness was grade III. The clinical assessment of total hip arthroplasty was done by numerical scoring system modeled on WOMAC scoring as described by Iwata *et al.* (2008). The outcome of procedure was assessed excellent in three cases that had a score of 3, good in one case with a score of 4 and poor in two cases with a score of 12. Gait and lameness grade had improved significantly in four cases and moderate in two cases. Denny and Butterworth (2000) opined that the outcome of the THA was 85 to 95 percent with less complication being seen as surgeon gained more experience.

Radiographic assessment scores made from standard hip extended radiograph as per Iwata *et al.* (2008) were the mean score of canal fill was 1.17 ± 0.48, cement mental fill was 1.00±0.37, presence of radiolucent line in and around the acetabular component was 0.83 ± 0.48, cement porosity was 0.83 ± 0.54 and position of cup was 1.17 ± 0.31. The clinical assessment scores that included the mean score of pain on palpation were 2.33 ± 0.56, early complication was 1.83±0.75 and late complication was 1.83± 0.70. The total score of radiological and clinical assessment of six cases of group II were 2, 24, 5, 9, 10 and 31 out of 40 points respectively with a mean score of 13.50± 4.67. The radiological assessment revealed excellent to good result wherein the scores were less than 10. The out come of procedure was assessed excellent in three cases, good in one case and poor in two cases ***(Table III; Plate I and Fig. 3).***

The mean ± S.E of functional outcome were 10.60±6.56, 20.20±4.07, 9.40±4.66, 9.00±3.18, 7.60±3.08 and 18.00±1.83 respectively. The mean ± S.E. of functional outcome postoperatively on day 2, 2nd week, 8th week, 24th week and 48th week 27.00±2.59, 14.00±1.80, 9.00±1.73, 6.67±2.34 and 5.67±2.56 respectively ***(Table IV; Plate II and Fig. 4)***. The dogs exhibited signs of pain free limb movement, full range of motion of the limb with increase in thigh muscle mass with no limb shortening except in two cases where implant luxation was noticed for which the implant was removed and made to form pseudoarthrosis as in case of excision arthroplasty (Olmstead, 1995). Kim *et al.* (2005) and Hulse and Johnson (2007) opined that THA was found to be successful treatment modality for painful hip with osteoarthritis and hip dysplasia. The animals showed partial weight bearing at rest and while walking. Iwata *et al.* (2008) assessed the long term functional outcome of THA and reported that 80 to 90 percent of canine total hip arthroplasty patients had excellent hip joint function.

The intra operative complication included BCIS. Significant decrease in rectal temperature, heart rate, pulse rate, MAP and SpO_2 after insertion of femoral component was noticed in patient that underwent THA. Intensive monitoring of anaesthesia was made so that before insertion of femoral component, the dogs were hyperoxygented, rate of fluid infusion was increased and pulsative lavage was made before cement insertion. The values returned to normal level within five minutes after femoral component insertion. Donaldson *et al.* (2009) reported that the perioperative complication associated with the femoral prosthesis implantation included transient hypotension, cardiac arrest and embolic pneumonia due to significant decrease in arterial O_2 tension and no significant change in heart rate, blood pressure, CVP and in blood gas assessment of pH, PCO_2, HCO_3 and $EtCo_2$. Arterial PO_2 decreased significantly. The decrease in PaO_2 was due to ventilation-perfusion mismatch, pulmonary artero-venous shunt or cardiac output rather than any form of micro or macro emboli or platelet aggression. The author also reported that intensive anaesthetic monitoring should be considered during THA since it might lead to bone cement implantation syndrome (BCIS).

The complication of THA is implant luxation noticed in two cases one case was due to retroversion of stem and another case due to poor cup positioning that occurred during the first post operative week. Parker *et al.* (1984) reported that out of 20 cases of canine THA, three cases had loosening of acetabular cup, two developed sciatic neurapraxia, three had degenerative mylopathy, five had excellent result, five had good and two had fair results. Ota *et al.* (2005) reported that in 248 canine total hip replacement, the overall complication rate was 12.7 per cent and included luxation 7 per cent, aseptic loosening of femoral implant 2.1 per cent, acetabular cup loosening 0.7 per cent and femur fracture luxation which occurred within six weeks of surgery. The predisposing factors for stem subsidence and retroversion might relate to ostectomy level, quality of trabecular bone, method of femoral preparation and stem impaction, stem alignment, femoral conformation and post operative activity (Nelson *et al.*, 2007).

Total hip arthroplasty was found to be effective technique in dogs which were more than 20 kg body weight where in the dogs gained pain free hip and returned to normalcy at second post operative week, with increased range of motion of the limb, symmetrical hip with improved gait and gaining of thigh muscle mass but this technique was costly and need surgeon's expertise. THA can also be performed in the dogs less than 20 kg body weight with micro hip prosthesis. The postoperative morbidity of THA could be minimized based on the expertise of the surgeon, weight of the dog, proper postoperative care and standard procedures.

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Table I- Selection of Animals

Animal No.	Breeds	Sex	Limb involved	Duration of illness	Criteria for selection of cases			
					Age	Body weight	Diagnosis	Grade
1	German shepherd	M	Left	1 year	6 Years	28	HD with Chronic luxation	Severe
2	Labrador	F	Left	2 months	8 months	25	HD with luxation	Severe
3	German shepherd	M	Right	1 year	8 years	30	Osteoarthritis	Severe
4	Labrador	M	Right	10 days	10 years	30	Luxation	Severe
5	German shepherd	F	Left	1 month	8 months	26	HD with luxation	Severe
6	Great dane	M	Right	3 months	1 year	45	HD with luxation	Severe

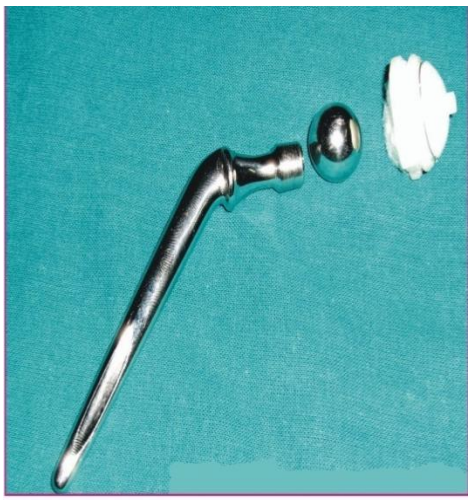

Fig 1- Total Hip prosthesis

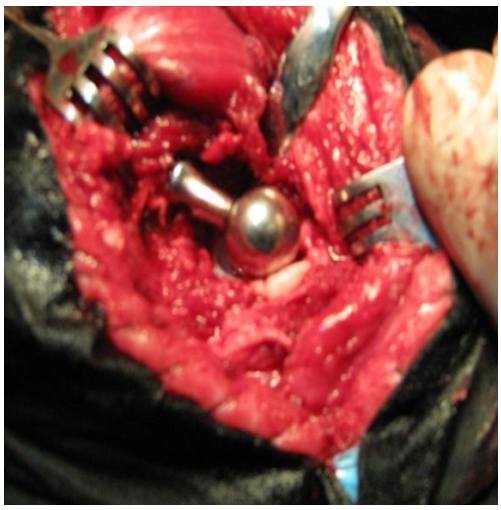

Fig.2- Implant positioning

Table II- Implant description and functional out come

	Femur stem Size (no.)	Head size (no.)	Acetabular cup (OD mm)	Cement (gms)	Outcome
1	6	+3 (14 mm OD)	20	20	Good
2	6	+3 (14 mm OD)	20	20	Poor
3	6	+3 (17 mm OD)	22	20	Excellent
4	6	+3 (14 mm OD)	20	20	Good
5	7	+3 (17 mm OD)	22	20	Excellent
6	9	+3 (17 mm OD)	24	40	Poor

Table III- Postoperative Radiological /Clinical Assessment Scores of THA (Iwata *et al.*, 2008)

Animal No.	Canal fill system	Cement mantel		Presence of radiolucent line over acetabulam	Cement porosity	Position of stem	Position of cup	Pain on deep palpation	Early complications	Late complication	Total score
		Stem	Cup								
1	0	0	0	0	0	0	0	2	0	0	2
2	2	2	2	0	0	2	4	4	4	4	24
3	0	0	0	1	0	1	0	2	0	1	5
4	1	1	1	0	0	1	1	1	2	1	9
5	1	1	1	1	2	1	0	1	1	1	10
6	3	2	2	3	3	2	4	4	4	4	31
Mean	1.17 ± 0.48	1.00 ± 0.37	1.00 ± 0.37	0.83 ± 0.48	0.83 ± 0.54	1.17 ± 0.31	1.50 ± 0.81	2.33 ± 0.56	1.83 ± 0.75	1.83 ± 0.70	13.50± 4.67

Table IV- Functional Outcome Assessment of Dogs THA (WOMAC Scoring)

Animal No.	Day 2	Week 2	Week 8	Week 24	Week 48	Mean
1	36	10	5	1	1	10.60±6.56
2	36	20	15	15	15	20.20±4.07
3	25	15	5	1	1	9.40±4.66
4	20	10	9	5	1	9.00±3.18
5	20	9	5	3	1	7.60±3.08
6	25	20	15	15	15	18.00±1.83
Mean	27.00 ±2.59	14.00 ±1.80	9.00 ±1.73	6.67 ±2.34	5.67 ±2.56	8.81 ± 2.88

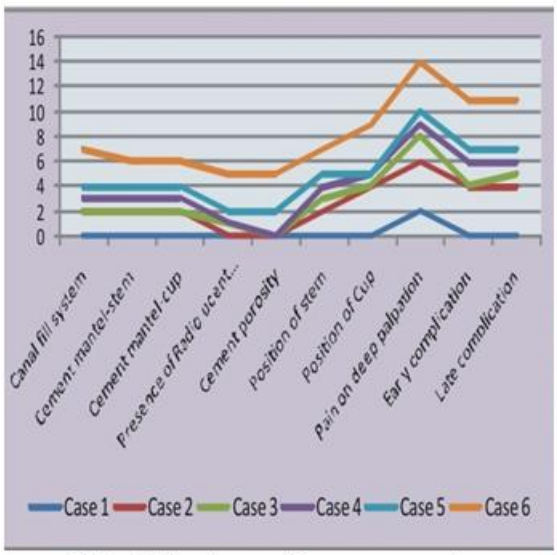

Plate I- Post operative assessment

Fig.3- Post operative Radiograph

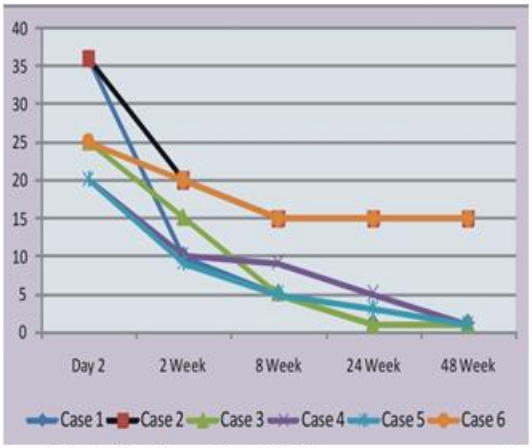

Plate II- Functional Outcome assessment

Fig.4- Post operative gait