Risk factors for Peri-implant fractures

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Abstract: Objective: To determine the risk factors for peri-implant fractures in orthopedic surgery, which is being used in our setup for fixation of different fractures. **Patients and Methods**: The study was conducted from May 2015 to December 2016. A total of 20 patients were retrospectively identified and included in the study. The inclusion criteria were patients of both gender, who presented to our unit with complaints of pain, deformity or inability to bear weight after fixation of fracture of either upper limb or lower limb. Exclusion criteria were age under 18 years old and infected implants. Type of fracture and implant used and adherence to AO trauma surgery principles were also assessed. **Results:** A total of 20 patients with peri-implant fractures. There were 11 males and 9 females with a mean age of 55.25 years (from 30 to 78 years). They presented with peri-implant fracture proximal or distal to DHS, Intramedullary nails, PFN, and conventional plates. **Conclusion**: The most important risk factors for peri-implant fractures are smoking, obesity, osteoporosis, bisphosphonates treatment and hyperparathyroidism.
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1. Introduction

Fractures around implants pose unique fixation challenges. Fractures around joint replacement prostheses are commonly called periprosthetic fractures, while fractures around plates, rods, or plates can be more generally termed peri-implant fractures. As more peri-implant fractures occur, the orthopedic surgeon needs to learn new methods to manage the specific problems involved **[Steven and Rabin, 2016]**.

Peri-implant fractures are the result of the same forces that cause fractures that do not have an implant present but additionally can be caused by factors specifically related to the placement of the implant or the presence of the implant. Osteoporosis, medications, and medical comorbidities all contribute to peri-implant fractures **[Curtin and Fehring, 2011]**.

Osteoporosis of the long bones challenges the orthopaedician in several ways. Amongst the difficulties encountered are the reduced bone mass, increased bone brittleness and medullary expansion, which must be factored in when deciding the type of surgical method to be used **[Singh et al., 2013]**.

Peri implant fractures of the femur are mostly reported fractures around the implants[Merkel KD, Johnson EW Jr,1986]. Peri-nail fractures have been reported in patients with proximal femoral fractures associated with short nails, with a higher incidence in uniaxial fixation than in biaxial **[Morris et al., 2012]**.

Peri-implant fractures have also been described in the forearm with osteosyntheses using plates in the pediatric population with an incidence of up to 7.3%. These may be due to falls, stress of the osteosynthesis material, iatrogenic causes, avascular necrosis, implant failure and pathological fractures [**Clement, et al., 2012]**.

Peri-implant tibial fractures are very rare complications which may be associated with moderate-high energy torsion forces, and also due to associated fibular fracture or to a fulcrum point which may cause a peri-implant fracture after a relatively low-energy trauma **[Mounasamy and Desai, 2012].**

Treatment includes medical conservative therapy; casting, bracing, and protected weight bearing are indicated only for stable fractures in which the implant is not loose and alignment of the prosthesis and the limb both is acceptable for adequate function when the fracture heals. Fixation options include intramedullary devices (rods, nails) or extra medullary devices (plates, screws) **[Phornphutikul et al., 2012]**.

If fixation of the fracture is chosen instead of replacement, the usual principles of fracture fixation must be followed. Stable anatomic fixation with preservation of soft tissue attachments through indirect reduction techniques should be achieved to obtain good results **[Schwarzkopf et al.,, 2013].**

The surgeon must choose the device that fits the patient best, with careful preoperative planning and intraoperative flexibility and creativity. **[Chmell et al., 1996].**

2. Patients and Methods

This study was conducted from May 2015 to December 2016. The inclusion criteria were patients of both gender, who presented to our team with complaints of pain, deformity or inability to bear weight after fixation of fracture of either limb. Exclusion criteria were age under 18 years and patients who have been proven to have infection. Initially 32 patients presented with complaints of pain, deformity or inability to bear weight after fixation of fracture of either limb were studied, 5 patients had infected implants,4 patients were under 18 years old and 3 had incomplete x- rays either pre operative or post operative. All these patients were excluded from the study. 20 patients were included and studied in detail with emphasis on mechanism of initial trauma, whether open or close fracture, type of initial treatment or fixation, co-morbidities, associated injuries or fractures, type of surgery and implant used, time interval between the first surgery and the new fracture, any pre operative or post operative complication, pre operative and post operative radiographs, post operative care specially weight bearing in lower limbs surgery, and recent event which led to peri-implant fracture. The time interval between the first surgery and the new peri-implant fracture was categorized into 4 categories; <6months, 6-12, 13-24 and >24months. Pre and post operative x rays were studied for type of fracture and type of implant used and adherence to AO trauma surgery principles were also assessed. Body mass index (BMI) were calculated for the 20 patients according to the following formula and approximated to the nearest decimal and categorized into 3 categories Normal from 18.5-24.9, overweight from 25-29.9 and obese >30.

$$\mathrm{BMI} = \frac{\mathrm{mass\ (kg)}}{(\mathrm{height\,(m)})^2}$$

3. Results

In our study we had a total of 20 patients with peri-implant fractures, they were 13 males (65%) and 7 females (35%). Their ages ranges from 30 to 78 years old.

11 of 20 peri-implant fractures were sustained spontaneously or after a low energy trauma while the rest of 9 occurred from a high energy trauma, the injuries occurred at a mean interval of 33.30 months (from 3.00 to 96.00 months) after the initial surgery. 7patients had interval time less than 6 months with percentage 35% out of our total patients, while 3 patients (15%) had interval between 6 to 12 months, only one patient was in the interval between 13 to 24 months, and 9 patients (45%) with interval more than 24 months. The most common bone had peri-implant fractures in our study was the femur with 10 out of 20 patients (50%), then the tibia with 4 patients (206%), humerus with 3 patients (15%), and 3 patients with radius peri-implant fractures (15%).

5 patients had intramedullary nailing (including gamma nail), 4 of them were for tibia with 43-A peri-implant fracture according to AO classification and one femur with gamma nail, with fracture (32-A).6 patients had DHS for various femoral fractures,4 of them were classified according to AO classification (31-A) and 2 were (32-A).2 volar plates were implanted for distal radius fractures with 23- A. 1 neutral (conventional plate) for mid shaft radius and had a peri-implant fracture distally (23-A). 3 Locking plate for humerus and with (12-A). 2 ds femur plate for femur with 31-A. only one case in our study had a combined fixation by bipolar and DCS and had mid shaft peri implant fracture (32-A). So, we had 15(75%) out of 20 cases with weight bearing implants while only 5(25%) had weight sharing implants.

10 patients had a history of bone softening disease; osteoporosis and/or hyperparathyroidism. While 4 patients (20%) were on bisphosphonate treatment for more than 5 years.8 patients out of 20 (40%) were heavy smokers i.e. more than 20 cigarettes per day and lasting for a period more than 10 years. 4 patients had two risk factors; bone softening disease and on bisphosphonate treatment. 2 patients had a bone softening disease and were heavy smokers. Only one out of our 20 patients had 3 combined risk factors; bone softening disease, on bisphosphonates treatment and was a heavy smoker. The mean BMI was 27.80 (ranging from 20.00 to 35.00).4 patients (20%) had normal weight, 7 patients (35%) had overweight and 9 patients (45%) were obese, as shown in table (1).

4. Discussion

Orthopedic implants are being used since last century, when used in fracture management they act as weight sharing devices. Chances of peri-implant fractures in weight bearing implants are more as compared with weight sharing devices as some of the body weight being taken by own bone in later **[Dhar, 2008]**.

In our study we found that Peri-implant fracture is the outcome of combination of causes like quality of implant, selection of implant, and quality of fixation, associated risk factors, geometry of the fracture and its pattern, treatment and post operative care and follow up.

Table (1): Demographic data of the total 20 study patients.

NO.	Age	Sex	BMI	Site	Implant	Interval (months)	bone softening disease*	Smoking	Bisphosphonates
1	37	f	31	tibia	IM Nail	5	—	—	—
2	43	m	27	tibia	IM Nail	3	—	yes	—
3	35	f	24	radius	volar plate	60	—	—	—
4	44	m	25	humerus	locking plate	96	—	yes	—
5	41	m	28	tibia	IM Nail	9	—	—	—
6	30	m	31	radius	neutral plate	36	—	yes	—
7	78	m	35	femur	bipolar + DCS	84	yes	—	yes
8	68	f	29	femur	locking plate	60	yes	yes	yes
9	68	f	34	femur	DHS	18	yes	—	yes
10	59	m	21	femur	DHS	9	yes	yes	—
11	76	m	32	femur	DHS	2	yes	—	—
12	60	m	29	humerus	locking plate	4	yes	—	—
13	65	f	31	femur	DHS	3	yes	—	—
14	76	m	27	femur	PFN	36	yes	yes	—
15	44	m	25	humerus	locking plate	96	—	yes	—
16	68	f	29	femur	locking plate	60	yes	—	yes
17	35	m	24	radius	volar plate	52	—	—	—
18	59	m	21	femur	DHS	9	—	—	—
19	43	m	27	tibia	IM Nail	3	—	yes	—
20	76	f	32	femur	DHS	6	yes	—	—

m: male, f: female, BMI: body mass index, IM: intra medullary, DHS: dynamic hip screw, PFN: proximal femoral nail, DCS: dynamic condylar screw, *Bone softening disease includes both patients with osteoporosis and hyperparathyroidism.

According to type of implant, based on the small number of patients in our study we found that the incidence of DHS peri-implant fracture is higher than that of proximal femoral nail with a ratio 6:1, in contrast to other study conducted by **Muller et al. 2016**, the risk more than three times higher within proximal femoral nail compared with DHS, while he stated no recommendations for implant removal prior to final osteosynthesis along with our study where the ratio of nail retaining to nail removal was 3:1 where the removed nail was because of its bending deformity of the nail.**[Muller et al., 2016]**.

Peri-implant fractures after osteosynthesis for proximal femoral fracture have been well-documented. Robinson et al. reported that the incidence of peri-implant fractures following the insertion of a compression hip screw for proximal femoral fractures was 4.46 per 1000 persons-years. In that study, about 50% of the fractures occurred around the distal end of the lateral plate **[Muller et al., 2016]**. Parker et al. also showed that a secondary fracture around the plate system occurred 1.9% of patients with an intracapsular fracture of the hip **[Parker at., 2013]**.

In our study 3 patients had peri-implant fracture 43-A on top of intramedullary nail additional locking plates and screws were added, Griffin et al evaluated the fatigue strength of common tibial intra-medullary nail distal interlocking screws of various nail manufacturers and concluded that to avoid fatigue failure, larger diameter screws need to be used and the addition of multiple screws adds resistance to early failure.

In our study osteoporosis was contributed in peri-implant fracture in 12 patients, Morphologic changes in osteoporotic bone include thinned cortices, decreased trabecular density, and decreased stiffness.

4 patients experienced peri-implant fracture with associated history of bisphosphonate use, Atypical fractures of the native femur are more likely to occur after 2 or more years of bisphosphonate use and within 1 year of the last prescription **[Schilcher et al., 2015]**. Classical Atypical femoral fractures can occur without an established association with bisphosphonate use, and we suggest that this may be also the cause for some atypical peri-implant fractures and stated previous association between bisphosphonates and atypical peri-implant fractures has been made.

The mean BMI associated peri-implant fracture in our study were 27.80, **Mounasamy and Pingal Desai et al., (2012)** stated a case of 303 pounds experienced peri-implant intramedullary fracture and stated that significant external rotation force and obesity could have caused this fracture, with increased stress at the interlocking screw site **[Mounasamy, 2012].**

Smoking have been associated in the history of 3

patients with peri-implant fracture, Lau et al found the incidence of nonunio8 or delayed unions in cigarette smokers to be twice that of non-smokerss, Schmitz and colleagues showed clinical evidence that smoking may be implicated in nonunions of diaphyseal fracture resulting from trauma**, Bown et al** looking at the role of cigarette smoking in the development of pseudoarthrosis is to 40% compared to 8% with non-smokers.

Bone softening diseases, including osteoporosis and/or hyperparathyroidism, have been associated with the history of 10patients with peri-implant fracture in our study, **Paul et al. 2011)** stated that Deficiency in vitamin D causes secondary hyperparathyroidism, high bone turnover, bone loss, mineralization defects, and hip and other fractures. Vitamin D3 supplementation causes a decrease of the serum PTH concentration, a decrease of bone turnover, and an increase of bone mineral density. Vitamin D3 and calcium may decrease the incidence of hip and other peripheral fractures in nursing home residents. Vitamin D3 is recommended in housebound elderly, and it may be cost-effective in hip fracture prevention in selected risk groups **[Paul et al, 2011].**

Conclusion

The most important risk factors for peri-implant fractures are smoking, obesity, bisphosphonates treatment and bone softening disease. The surgeon must keep in mind patient factors that increase the chance of peri-implant fracture, including age, gender and comorbidities. Finally, routine follow-up of patients is critical in identifying those at high risk of refracture.

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