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Mechanical Complications of Osteosynthesis in a Developing Country: Frequency and Risk Factors

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Abstract

Aim: Determine the frequency and risk factors of mechanical complications after osteosynthesis (MCO) in our department.

Patients and Methods: This is a five-year prospective study. All patients presenting with MCO during this period were collected. Errors in operative indications, technical defects, material problems and non-compliance with postoperative instructions were studied. MCO occurring during infections of the operating site were excluded.

Résults: 44 cases out of 475 osteosynthesis were collected, i.e. 9,26%**.** They were 33 males and 11 females with a mean age of 34,3 years **(18-65).** The MCO were in the femur in 26 cases, followed by the tibia (7 cases). The most frequently observed MCO **occured after** centromedullary nailing (n=26) and screwed plate (n=8). The failures consisted in device dismantling (14 cases), implant rupture (12 cases), migration (11 cases), torsion (4 cases), and in 3 cases the device was in place but ineffective. The risk factor analysis included non-compliance with postoperative instructions in all patients, use of salvage implants ($Chi^2 = 29,94$, $p = 0.0002$) and poor surgical indications and/or technical defects during osteosynthesis ($Chi^2 = 37,03$, $p = 0.01$). Non-unions and malunions were the consequences of these MCO.

Conclusion: The occurrence of a MCO is a complex issue, involving the initial and continuing medical training of the orthopaedic surgeon**,** the equipment of the department, the organisation of meetings or staffs allowing to discuss operating records, the respect of operating procedures and a regular follow-up of operated patients. Respect of these requirements should reduce this complication disappointing for the patient and his surgeon.

Keywords: Osteosynthesis; Fracture; Dismantling; Mechanical Complication

Introduction

The mechanical complications after osteosynthesis are defined as any spontaneous and harmful change in the assembly that occurs during the evolution of an osteosynthesis and most likely compromising the consolidation process [1].

Osteosynthesis has emerged as a very good way for treating fractures. It has the advantage of good reduction and solid stabilization of the fracture site, allowing mobilization or even early loading and consolidation [2]. The mechanical complications of osteosynthesis occur at very different times and result in malunion or non-union**.**

We conducted a study on the mechanical complications of osteosynthesis aiming to determine the frequency and risk factors of these mechanical complications of osteosynthesis observed in our department.

Patients and Methods

We conducted a prospective study over a five-year period (January 1, 2011 to December 31, 2015) in our service. The diagnosis of mechanical complications of osteosynthesis was suspected when noticing limb deformity, protrusion of the osteosynthesis material or functional discomfort. Confirmation was made by standard radiograph. A complete study of the patient's file was made, reviewing the surgical indications, the initial management, the material used and its origin. The complications studied concerned

the dismantling of screwed plates and external fixators, ruptures of plates, nails and pins and finally the migration of nails and pins. The Kuntscher type centromedullary nails still inserted with opening were unlocked and indicated in diaphyseal fractures type A, B and C2 of the Osteosynthesis Association (AO classification). External fixator was indicated in open fractures and complex (C1 and C3) diaphyseal fractures of long bones were used to treat condylar fractures of the femur. The investigated risk factors were compliance to the indication, surgical technique, and re-use of a previously used implant. The basic principles of osteosynthesis of AO fractures were considered as the Gold standard. Adherence to post-operative recommendations was sought in all patients. The recommended discharge time for lower limb osteosynthesis and the resumption of strength activities in the upper limbs were also evaluated. Patient age, patient medical history, and AO fracture type were also studied. Each patient was informed of the occured complication and of the different possible treatment modalities with their advantages and disadvantages, and gave informed consent. The treatment of these complications consisted of: simple removal of the material in case the fracture was consolidated, removal and correction by osteoclasia or osteotomy in case of vicious consolidation, removal of implant and new osteosynthesis in case of pseudarthrosis due to to rupture, torsion, dismantling or migration of implants. All mechanical complications of osteosynthesis resulting from osteosynthesis performed in the department during the study period were included. Mechanical complications of osteosynthesis occuring on surgical site infection and osteosynthesis in septic environment were excluded. The data were analyzed using the Epi-Info 2008 software version 3.5.1. Comparison of the proportions of implant types causing mechanical complications of osteosynthesis to the observed risk factors used the Chi-Square (ch^2) test with a significance level of 0,05.

Frequency

During the study period, we performed 475 osteosyntheses and 44 mechanical complications were recorded. This represented a frequency of 9,26%.

Characteristics of the Series

Mechanical complications occurred in 33 males (75%) and 11females (25%) with a sex ratio of 3. The mean age of the series was 34,3 years (extremes: 18 and 65 years). The etiology of fractures was dominated by road traffic accidents in 31 cases (70.5%), followed by domestic accidents (5 cases, 11,4%), work accidents (4 cases, 9.1%), aggression (3 cases, 6.8%) and one sports accident. CMOs in the lower limbs were the most common, with 26 cases (59,1%) in the femur and 7 cases (15,9%) in the tibia. The fracture most frequently observed was the transverse type (A3) in 25 cases (56,8%) and the torsion wedge type line in 10 cases (22,7%). Eight patients (18.2%) had an open fracture at the time of the initial trauma. All of the patients operated on with MCO were in good general condition with ASA 1 or 2.

Characteristics studied	Staff (%)
Frequency	44/475 (9,26%)
Sex	
Male	33 (75%)
Femal	11 (25%)
Sex ratio (H/F)	3
Age (years)	
Middle Ages	34,3
Extremes :	18 et 65 ans
Most affected slice	18 à 35 ans (65,9%)
Traumatic etiology	
Road traffic accident	31 (70,5%)
Accident at work	4 (9,1%)
Aggression	3 (6,8%)
Domestic accident	5 (11,4%)
MCO Headquarters	1 (2,3%)
Siège de la CMO	
Femur	26 (59,1%)
Tibia	7 (15,9%)
Humerus	6 (13,6%)
Forearms	5 (11,4%)
AO Classification	
A 1	4 (9,2%)
A2	1 (2,3%)
A3	25 (56,8%)
B2	10 (22,7%)
B3	2 (4,5%)
C1	2 (4,5%)
Skin opening	
Yes	8 (18,2%)
No	38 (81,8%)
General condition of patients (ASA)	
ASA 1	38 (86,4%)

ASA 2	6 (13,6%)
Implants used	
Nail (Kuntscher)	27 (61,4%)
Screwed plate	8 (18,2%)
External fixer	4 (9,1%)
Plate blade	3 (6,8%)
Brooch	2 (4,5%)
Type MCO	
Rupture	12 (27,3%)
Removal	14 (31,8%)
Migration	11 (25%)
Torsion	4 (9,1%)
Inadequate device	3 (6,8%)

Table I: Features of the 44 MCO series.

The most frequently involved implants were Kuntscher nail 27 (61,4%) and the screwed plate 8 (18,2%). Others were external fixator (4 cases), 130° condylar plate blade (3 cases) and two pins (2 cases). The types of MCO observed were device dismantling 14 cases (31,8%), implant rupture 12 cases (27,3%), migration 11 cases (25%), and torsion and failed settings (Table I).

Description of MCO

The study recorded 14 dismantlings of the device. These dismantlings often concerned the screwed plate (7 cases) and the external fixator (4 cases). Two disassemblies of the device were observed after centromedullary nailing and during 130° plate blade osteosynthesis. The Kuntscher nail was the most fractured implant (9/12 fractures). One case of rupture was observed after respectively screw plate, plate blade and pin osteosynthesis. Thie Kuntscher nail was also incriminated 9 times out of the 11 cases of migration observed. All implant torsions (n=4) were observed after Kuntscher nailing of the femur. In three cases with Kuntscher nailing the nail did not correctly stabilise the distal fragment (Table II).

	Implants en cause					
Type MCO	**Nail clou**	**PV**	**broche**	**FE**	**LP130°**	**Total**
Rupture	9	1	1	-	1	12
Removal	2	7	-	4	1	14
Migration	9	-	1	-	1	11
Torsion	4	-	-	-	-	4
Inadequate device	3	-	-	-	-	3
Total	27	8	2	4	3	44

Table II: Distribution of MCO and implants used.

Risk Factors

The risk factor analysis found that 13 patients in the series were found to be non-compliant with postoperative instructions. This factor was not statistically significant (Table III).

On the other hand, non-respect of the operating technique was incriminated in 27 cases (65,9%). This factor was statistically significant during the study ($Chi^2 = 37,03$, $p = 0,01$).

Concerning the cause of the MCO, early walking was incriminated in 27 cases (61,4%), early resumption of function in 8 cases (18,2%), technical defect in 6 cases (13,6%).

Re-use of previously used osteosynthesis material was also a specific factor in our series ($Chi^2 = 29,94$, $p = 0,0002$). It was found in 27 patients in the series (54,5%) (Table III).

Risk factors	Nomber (%)	P (value)
Adherence to post-operative instructions		
Yes		*p=0,2*
No	13 (29,5%)	
No deposit	29 (65,9%)	
	2 (4,5%)	
Respect of the operating technique		*p = 0,01*
Yes	27 (54,5%)	
No	14 (31,8%)	
Limit	6 (13,6%)	
Cause of MCO		*p= 0,0002*
Early walking (MI)	27 (61,4%)	
Technique not respected	6 (13,6%)	
Resumption of function (MS)	8 (18,2%)	
None	3 (6,8%)	
Recovered implants		*p = 0,0002*
Yes	27 (54,5%)	
No	14 (31,6%)	
Unknown	3 (6,8%)	

Table III: Risk factors studied.

Some implants were re-used after a first use. These were the Kuntscher nail, the screwed plate and the external fixator. The pin was the only osteosynthesis material that had not been re-used. Re-use of previously used osteosynthesis material was a specific factor ($Chi^2 = 29,94$, $p = 0,0002$). It was found in 27 patients in the series (54,5%) (**Table IV**).

	Implants re-use			
Implants	**Yes**	**No**	**Unknown**	**Total**
Nail	15	9	3	27
External fixer	4	-	-	4
Pins	-	2	-	2
Plate Blade 130°	1	2	-	3
Screwed Blade	7	1	-	8
Total	27	14	3	44

Table IV: Distribution of recovered MCO and implants.

Treatment

All of our patients have been reoperated for correction of the complication encountered. In 54.5% of the cases, the revision consisted of an ablation of the material associated with a new osteosynthesis. In 12 patients, after removal of the material (ROM), we performed a conservative treatment by plaster. The patients were **re-**operated on average 2 times (extremes= 2 and 4 times).

In the case of ruptured implants, the management consisted of ablation of the open material and its replacement with a new nail of the same diameter as the diaphyseal shaft (8 cases; 66.2%). Four bent nails were bent and were corrected by external maneuvers before removal of the osteosynthesis material and replacement with new nail (Table V).

Consequence	Cure+ Osteosynthesis	Embedding	ROM+ osteosynthesis	ROM +Plâtre	Total
Rupture	2		8	2	12
Removal	1		7	6	14
Migration	1	1	6	3	11

Torsion			4		4
Inadequate device			1	2	3
Total	4	1	26	13	44

Table V: Distribution of surgical revision procedures.

As for the responsibility for dismantling, the surgeon and the patient shared equally. Patient satisfaction had been studied. Twenty-two patients were disappointed with the occurrence of CMOs, 17 remained undecided, while two refused first-line care before agreeing to be reoperated.

Discussion

The mechanical complications of osteosynthesis have been described in the literature [3-5]. They depend on the type of fracture and its mode of fixation, but also on possible problems of consolidation, factors often associated in the occurrence of a mechanical failure of the osteosynthesis. The frequency of mechanical complications varies between 6 and 18% [2]. In Morocco, Essadki et al. [6] reported 7, 5% of mechanical complications of osteosynthesis out of 413 osteosyntheses with per screwed in 11 years. In Congo, Moyikoua et al. [7] reported 9% mechanical complications out of 314 osteosynthesis over a three-year period. In Côte d'Ivoire, Gogoua et al. [2] collected 26 cases in 7 years. In Guinea, Lamah et al. [1] reported 8,9% of mechanical complications out of 178 osteosyntheses over a period of 2 years.

In our series, we had 9,26% of mechanical complications out of 475 osteosyntheses in five years; males were the majority in our series (75%). The average age of the series was 34,3 years (extremes: 18 and 61 years). In the Gogoua's series [2], the mean age was 32 years, which is close to our series. For Essadki [6], the mean age was 36 years with extremes of 12 and 64 years. These authors stress the frequency at extreme ages. This means that age play a part in the mechanical complications of fractures. In children, while there is the advantage of the thickness of the periosteum, which often limits displacement, the thinness of the cortex does not allow good anchoring of the screws. On the other hand, in the elderly, the bone is generally porous, preventing from a good holding of the screws in the cortex.

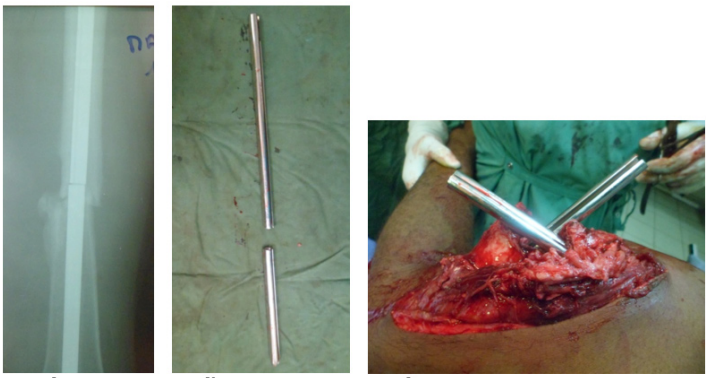
Osteoporosis remains an important factor in all series [3,6,8,9]. The femur is the segment most affected by these complications. This segment is part of the supporting limb. Too early loading was found in 61,4% of patients in our series. This mechanical cause was noted in all patients in the Lamah [1], Gogoua [2], Essadki [6] and Moyikoua [7] series. In implant deformities and fractures, we believe that there is a relationship between the weight, the diameter of the nail and the early loading. Essadki et al. [6] recorded 7,5% of mechanical complications in femoral diaphyseal fractures treated with screwed plates.

In the Moyikoua et al. [7] series, 12 out of 22 patients had a complex or multi-fragmentary fracture. Gogoua et al [2] had 3 femoral extremity fractures and 3 multi-fragmentary fractures in which no bone graft had been performed. We recorded 61,4% of the mechanical complications on Kuntscher nails. This is an unlocked nail that is inserted through an open way in our department. The lack of locking is responsible for the observed nail migrations. Among these Kuntscher nails, those of small diameter are generating ruptures, leading to pseudoarthrosis and torsion during early loading requiring their replacement before consolidation.

Mal-unions was found in 63,6% of patients in our series, 54,54% in the series of Essadki et al. [6], 20,90% in the series of Burny et al. [3] and 9,2% in the series of Moyikoua [7]. Pseudarthrosis is thought to act by the same mechanism as comminution of the fracture, by increasing the stress on the implant.

For Burny [3] and Rüedi [10], the existence of an inter-fragmentary diastasis is a frequent cause of mechanical failure. Diastasis results in to high bending stresses on the material exposed to plastic deformation and then fatigue failure. For this reason, Müller [11] rightly advocated the grafting of bone defects.

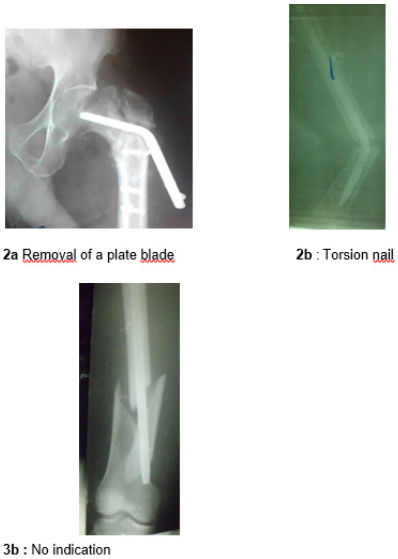
Concerning the time for consolidation, 61,4% of our patients loaded the fractures of the lower limbs at an early stage between 30 and 90 days and 18,2% resumed to manual function at an early stage. Gerald [12] and Lamah [1] found an average delay of 3 months for material removal and 6 months for fractures. A patient painfree gains early confidence in his limb and lets himself go without the advice of his doctor (Figures 1a,b,c).



1a 1b 1c

Figure 1: a- Rupture of a Kuntscher nail, b- nail broken after extraction c- intraoperative extraction of the broken Kuntscher nail.

For implant-related factors, in our series, 27 mechanical failures were related to poor implant selection. The material-related factor is recognized in all series [3,6-8]. For better stability, the implant must be sufficiently wide and thick, its rigidity depending on its dimensions. In addition, certain techniques such as open-unlocked centromedullary nailing, which do not ensure good stability of the fracture site and is sources of disassembly, should be abandonned (Figures 2a, 2b and 2c). Among the complications observed in our series, this Kuntscher nailing is responsible for the high rate of CMOs. Wami et al. [13] observed this in a reported case.



2a Removal of a plate blade **2b** : Torsion nail

3b : No indication

Figures 2a, 2b and 2c: Some MCO of the series.

In our series, 61,4% of mechanical complications occur on re-used materials that cause early fatigue and rupture of the implants.. Nail fractures and implant implication are frequent and reported by many authors [14-16]. All of our patients were reoperated for the correction of BMCs. The intervention consisted of either a simple ROM when the case was consolidated, or an ROM associated with a cure and osteosynthesis in the case of mal-union or implant rupture. In the Essadki [6], Moyikoua [7] and Riemer [17] series, revision becomes essential when one or more factors may contribute to non consolidation or when there are radiological signs of pseudarthrosis.

These different aspects of mechanical complications should lead the surgeon to question his share of responsibility in all mechanical failures of osteosynthesis. The lack of homogeneity of the implants studied is the limit of our study.

Conclusion

The mechanical complications of osteosynthesis are still frequent and difficult problems for the initial and continuing medical training of African orthopaedic surgeons and **for** the equipment of Orthopaedic-Traumatology departments with modern materials. They could be minimized by a rigour in the operative indications, the adequate choice of osteosynthesis equipment and a regular follow-up of patients.

Conflit d'intérêt :

Les auteurs déclarent n'avoir aucun conflit d'intérêt.

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