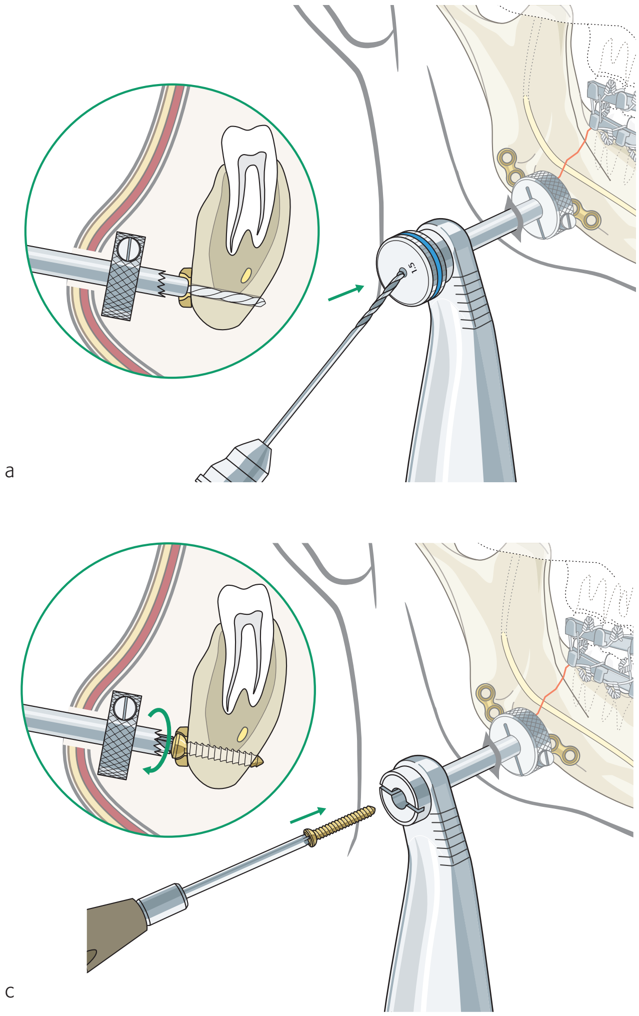

Fig 1.4.3-34a–c Transbuccal fixation technique.
a Transbuccal drilling.
b Depth measurement.
c Transbuccal screw insertion.

Resorbable plate instrumentation: In the majority of available systems they can only be contoured if they are heated first. Placing the plate into a water bath permits heating of the plate to the point that it can be contoured. While the water bath heater is not sterile, the water bath tray and water bath sterility cover are. Sterile water is placed into the tray and the heater turned on (**Fig 1.4.3-35a–b**).

Graphic cases: The organization of plates, screws, and instruments into graphic cases is a substantial improvement. The current graphic cases are so numerous in variety and versatile in their modular capability that there is a "place for everything and everything in its place" no matter how large or small the operating room or hospital. Moreover, the modular design permits adaptability or customization of storage for virtually every surgeon, procedure, or space problem (**Fig 1.4.3-36a–b**).

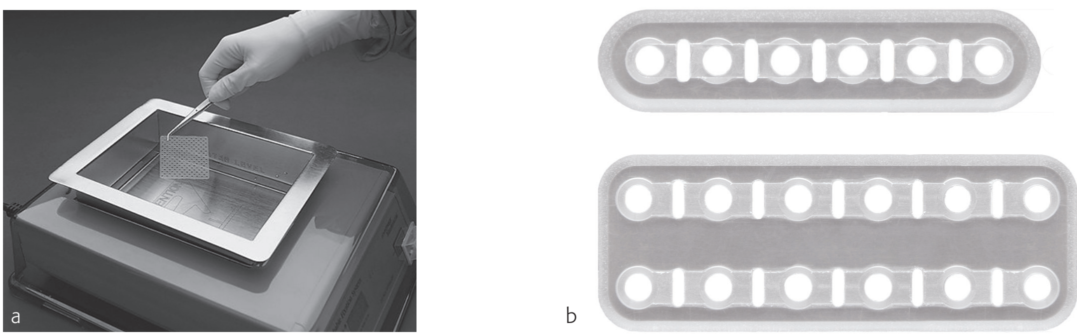

Fig 1.4.3-35a–b Resorbable plate instrumentation.
a Water bath.
b Resorbable plates.

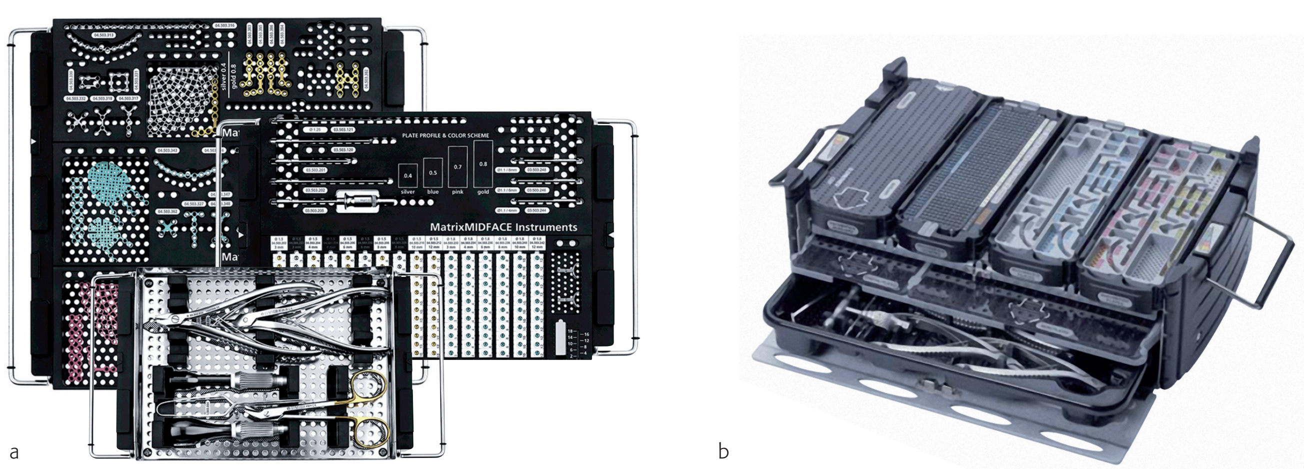

Fig 1.4.3-36a–b Instrument and implant sets.
a MatrixMIDFACE international set.
b MatrixMIDFACE US set.

7 Power tools

Power tools are used to drill and cut bone. The power instruments of the past have been improved, with a more lightweight, compact, and efficient air-driven rotary power source, as well as the introduction of self-contained (battery) power sources for both drills and screwdrivers (**Fig 1.4.3-37a–b**).

a b

Fig 1.4.3-37a–b Power tools.
a Colibri.
b E-Pen.

Acknowledgements
Thanks to Regan Barber, Valerie Biggers, Ralph Zwirnmann, Bryan Griffiths, Chuck Goudy, Paul Ciccone, and Samuel Leuenberger for their efforts in drafting the tables for plates, screws, and equipment.

Author Richard H Haug

1.5.1	**Goals of CMF trauma care**	**83**
1.5.2	**Indications for surgical, nonsurgical, or no treatment of craniomaxillofacial fractures**	**85**
1.5.3	**Presurgical and postsurgical considerations, treatment planning**	**87**
1.5.4	**Principles of surgical fracture management**	**89**
1.5.5	**Biomechanics of the bone-implant-unit**	**91**
1.5.6	**Principles of stabilization: splinting, adaptation, compression, lag screw principle**	**95**
1.5.7	**Dental and alveolar trauma**	**103**
1.5.8	**Teeth in the fracture line**	**109**
1.5.9	**Implant removal and stress protection**	**111**
1.5.10	**Techniques of mandibulomaxillary fixation (MMF)**	**115**

Authors Michael Ehrenfeld, Joachim Prein

1.5.1 Goals of CMF trauma care

The ultimate goal of modern craniomaxillofacial trauma care is immediate or early restoration of both form and function of all structures of the face and cranium, with complete, predictable, and complication-free healing. This also applies to corrective bone surgery of the facial and cranial skeleton as well as for ablative and reconstructive tumor surgery.

Depending on the type and extent of craniofacial injuries or pathology, this goal cannot always be achieved. For instance, when specific tissues are severely damaged or lost, like eyeballs, teeth, and nerves, anatomy or function cannot be restored. However, even in these severe cases, the patients should be treated as completely as possible; always keeping the ultimate goal in mind which is to reach the best possible result. The crucial goal of modern craniomaxillofacial surgery is to achieve the highest possible quality of life by returning the patients to the best possible condition.

Modern trauma care as well as corrective bone surgery and tumor surgery are based on a number of prerequisites:

- Interdisciplinary approach involving all specialties needed according to the specific injuries of the patient
- Adequate imaging
- Individual treatment planning based on science and individual experiences
- Adequate timing of surgery
- Treatment, especially surgery, should be performed according to the highest standards, involving modern techniques and equipment. In craniofacial traumatology, this implies use of modern internal fixation systems, tissue (bone) replacement materials, tissue transfer, and resuspension of soft tissue to bone as standard components. However, endoscopy and navigation may be used in special circumstances.
- Case-adapted aftercare and follow-up.

All of the above-mentioned points are almost equally important to realize a state-of-the-art treatment outcome.

Authors Michael Ehrenfeld, Joachim Prein

1.5.2 Indications for surgical, nonsurgical, or no treatment of craniomaxillofacial fractures

Craniomaxillofacial fractures may be treated in different ways. In many instances there is more than one option for dealing with a given clinical situation or problem. In principle, three treatment options exist for managing CMF fractures. They are:

- No treatment
- Nonsurgical treatment
- Surgical treatment

Within each of the three treatment options there are subgroups with different treatment algorithms, for example, within the surgical group, rigid versus nonrigid fixation.

No treatment means no active treatment and no structured follow-up.

Nonsurgical treatment for many years was also called conservative treatment or closed treatment. It means fracture treatment without opening skin or mucosa and without direct visualization of fragments. Within this group there is a wide range of treatment possibilities, such as soft diet and observation, functional treatment with orthodontic appliances, mandibulomaxillary fixation (MMF) with wires, arch bars, or other MMF devices, sometimes with subsequent functional therapy. It is important to note that "observation only" and follow-up, for example in a greenstick-fracture in a child, or in nondisplaced fractures, is regarded as treatment and not as no treatment.

The terms surgical treatment, open treatment, and operative treatment are interchangeable. Surgical fracture treatment typically involves these steps:

- Exposure of the fracture site
- Reduction of the fragments
- Internal fixation

Open reduction and internal fixation (ORIF) always involves soft-tissue surgery and may involve tissue transplantation and the use of grafts or alloplastic tissue (bone) replacement. Generally all treatment options for facial fractures can be associated with specific complications and adverse effects. A surgeon must be familiar with these and be able to communicate them to a patient in an appropriate manner via the informed-consent process.

The primary goal of CMF fracture care is a predictable, safe, undisturbed, and complication-free healing. Sometimes this goal can be reached with more than one treatment option. There are situations when the patient's comfort is a major factor with dominant impact on the treatment decision; for instance, in a situation in which a patient can choose between a nonsurgical treatment of a mandible body fracture with arch bars and four weeks of MMF or a surgical treatment. The latter may have more specific surgical complications but allows function immediately or soon after surgery. In addition, the ability for cooperation is a factor in the decision, especially in elderly patients.

It is critically important to always remember that surgeons do not only treat fractures but patients with fractures. Therefore, decision making on treatment choices involves more than the type and the severity of the fracture. The general health status, intercurrent diseases, age, estimated compliance, social status of patients, and their wishes and expectations all need to be considered.

Of various treatment options, the ones selected are those most likely to provide the best possible outcome.

In the mandible, no treatment and observation only may be considered for incomplete and/or undisplaced fractures without malocclusion, pain, or other functional disturbances with no additional pathology, such as dentigerous cysts, at the fracture site. In the midface this applies for lateral midface (zygoma) fractures with minimal or no displacement, undisplaced zygomatic arch and orbital wall fractures. In the central midface the same is true for nasal fractures and nasoorbitoethmoid (NOE) fractures with little or no displacement. Frontal sinus fractures, cranial vault fractures, and skull base fractures without displacement or with minimal displacement and without additional pathology also do not require surgery. Mobile or displaced (impacted or incomplete) Le Fort type midface fractures should always be treated surgically in adults. Here nonsurgical treatment should be limited to children with greenstick fractures.

Nonsurgical treatment with short-term MMF and/or orthodontic treatment should be considered in adults for undisplaced condyle and condylar head fractures associated with malocclusion, pain, or functional deficits. Undisplaced fractures of the mandibular body with pain and/or functional problems can also be successfully treated with MMF and sometimes subsequent functional therapy. Nonsurgical treatment of body fractures in adults requires longer immobilization, approximately 4–6 weeks. Therefore, many patients request open surgery and internal fixation for comfort and improved function. For children younger than 12 years, nonsurgical management with MMF for undisplaced and displaced condyle fractures with functional problems and/or pain is still considered the treatment of choice, although recently attempts have been made toward surgical treatment especially for dislocated fractures.

For central midface fractures with malocclusion, mobility, pain, and/or other functional problems there is no possibility for fracture treatment with MMF alone in either adults or children, except for isolated alveolar process fractures.

In both the mandible and the midface, surgical treatment is indicated for all fractures with more than minimal displacement. They require open reduction, internal fixation, and/or reconstruction of bony subunits of the face, such as orbital walls, nose, and zygoma.

For all fractures with a potential impact on the occlusion, it is of paramount importance to apply MMF in proper occlusion before performing internal fixation. An internal fixation with plates and screws should be three-dimensionally stable. Malocclusion resulting from an improperly reduced osteosynthesis cannot be corrected by keeping a patient in MMF postoperatively or using elastic traction.

Antibiotic prophylaxis is indicated in major injuries, especially for those with compromised soft tissues, such as avulsive crush or gunshot injuries. In less severe injuries antibiotic prophylaxis is optional. Antibiotics are routine in the treatment of all fractures with signs of infection.

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1.5.3 Presurgical and postsurgical considerations, treatment planning

Meticulous preparation and treatment planning is essential to achieve the best possible results in trauma care as well as in corrective and reconstructive surgery of the musculoskeletal systems. It involves:

- Detailed clinical examination
- Adequate preoperative imaging
- Data analysis and development of a treatment plan including alternatives
- Communication with the patient
- Informed consent

These steps need to be documented and the data needs to be archived according to local legal regulations. Preoperative checklists have been introduced to simplify and standardize the process.

Not only severity and type of fractures, defects or malformations, but also the individual patient's personality, age, sex, and general condition are major factors for treatment planning. Thus an osteosynthesis or reconstruction technique has to address both the characteristics of a fracture and the characteristics of a patient.

Personality of the patient: Highly educated and intelligent patients tend to have a better compliance with therapeutic measures and advice while those with a lower education level and social standard may be negligent in their postoperative behavior. These patients require closer supervision and more reliable techniques, for instance a more rigid fixation in a trauma case.

Age and sex of the patient: Healing, especially bone repair is usually better in younger patients. In addition, the bite forces of young dentate men are higher compared to young dentate females. Bite forces in general tend to be smaller in older individuals. Bite forces tend to be higher in dentate compared with partially dentate or edentulous individuals. As a consequence, internal fixation should be more rigid in young fully dentate patients.

Medically compromised patients: Patients with metabolic diseases such as diabetes, allergies, bleeding disorders, and those with substance abuse must be treated with particular caution. Metabolic diseases, disturbances of liver function, and excessive hematoma formation may effect postoperative soft-tissue and bone healing.

Psychiatric and neurological diseases (such as epilepsy) and substance abuse are contraindications for postoperative mandibulomaxillary fixation (MMF).

Postoperative aftercare includes clinical controls and adequate imaging. Intra- or postoperative imaging needs to be performed and documented to prove the quality of reduction and the adequacy of hardware placement (quality control). This may be done with 2-D imaging, usually x-rays, in two planes for simple fracture scenarios, such as simple fractures of the mandible. For more complex fracture and reconstruction scenarios, including all orbital fractures with orbital wall repair, 3-D imaging, usually with CT or cone beam CT, has become almost the therapeutic standard.

Authors Michael Ehrenfeld, Joachim Prein

1.5.4 Principles of surgical fracture management

Besides meticulous planning, surgical fracture repair involves four sequential surgical steps:

- Adequate exposure
- Fragment reduction
- Adequate internal fixation
- Meticulous wound closure

Adequate exposure: The surgical approach is chosen according to localization and severity of fractures. In general, a surgical approach should be as small and hidden as possible, but must give adequate access for bone handling and placement of osteosynthesis material.

Fragment reduction: The goal of fragment reduction is establishing preinjury bone anatomy prior to internal fixation. Indirect fragment reduction is possible, for instance through applying arch bars and putting the patient into occlusion. Direct fragment management with the help of reduction forceps, bone hooks, or bone-anchored devices such as a Caroll-Girard device, and combinations of these are possible as well. The fragments are held in place while internal fixation is performed. For all fractures with a potential impact on the occlusion, such as mandibular or Le Fort type fractures, temporary intraoperative mandibulomaxillary fixation (MMF) is recommended.

Adequate internal fixation: Adequate hardware first must be selected, according to the personality (severity) of the injury and the personality of the patient. In addition it includes appropriate hardware placement and fixation according to the expected biomechanical stresses and forces in the fracture areas.

Meticulous wound closure: This includes wound closure in layers, including muscle and periosteal resuspension. The need for meticulous soft-tissue resuspension increases with the amount of soft-tissue stripping for exposure, reduction, and fixation. The indication for wound drainage should be considered, but is always an individual surgical decision. In cases with soft-tissue defects, such as gun-shot injuries, immediate vs delayed soft-tissue reconstruction needs to be discussed.

Authors Adrian Sugar, Robert Bentley

1.5.5 Biomechanics of the bone-implant-unit

To obtain appropriate stability in fracture treatment it is essential to consider not only the factors pertinent to the type of fracture and the soft-tissue environment in which it has occurred but also patient related factors. These factors include the build of the patient, intercurrent illness (comorbidity), smoking and alcohol habits, occupation, personality, and compliance of the individual patient, all of which affect the appropriate choice of implant. The chosen implant must accommodate the expected magnitude and duration of load for each specific case (**Fig 1.5.5-1**). The specific danger is underestimation of certain loading conditions such as fractures of the mandibular condyle and the atrophic mandible. While miniplates in the body of the mandible can perform perfectly if loaded in tension, their stabilizing function may be insufficient if placed at a site subjected to various kinds of load. In addition, the requirements that the fixation device must meet change in function and bone anatomy over time. During a physiological and undisturbed healing process bone gradually takes over the load across the fracture site and the implant becomes unloaded. If the healing process is delayed, for example by patient related factors such as smoking, poor oral hygiene, or compromised healing in immuno-compromised cases, the estimated biomechanical situation may be different due to prolonged loading condition. As a consequence, a small implant may undergo fatigue failure. Such an osteosynthesis, in which implant and bone need to share the load, is called a load-sharing type of fixation.

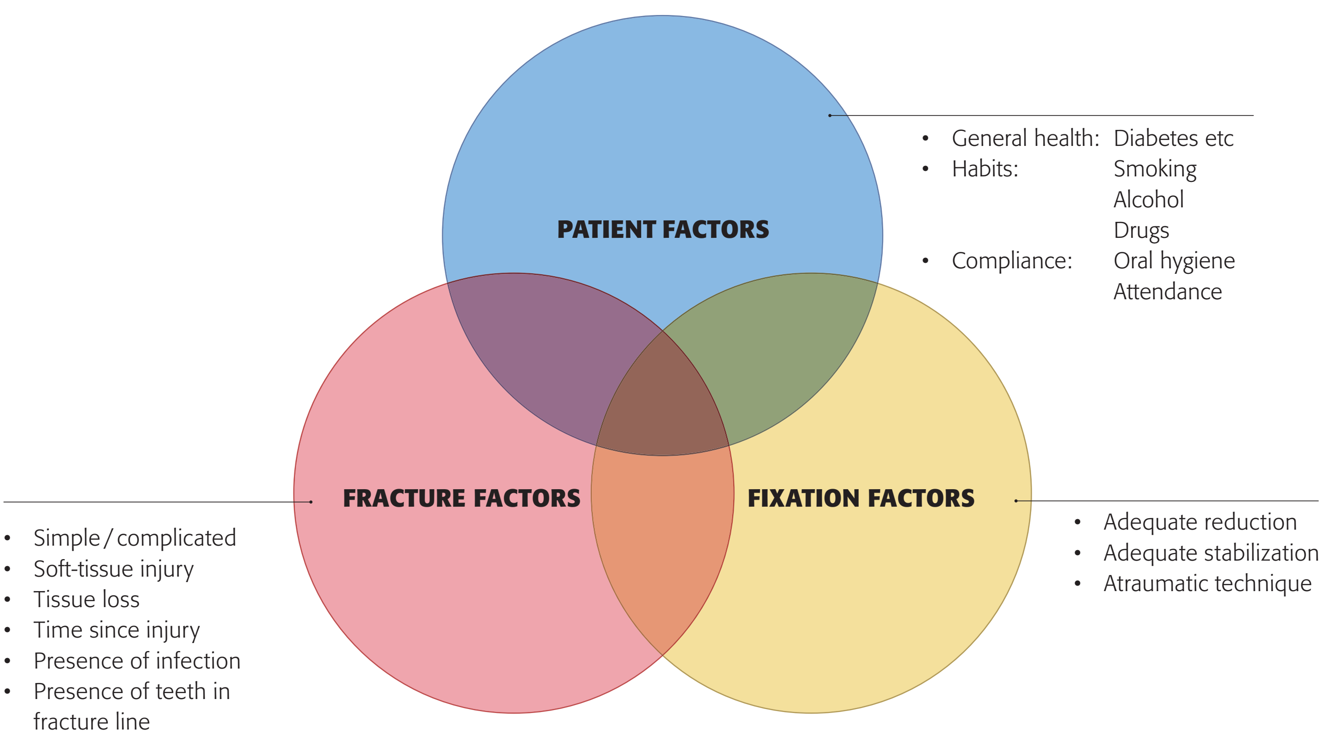

Fig 1.5.5-1 Interrelationship of patient, fracture, and fixation factors in fracture healing.

The fracture fragments and implants should be considered as one single unit which must be able to deal with the type and degree of load exerted across the fracture. A relatively undisplaced well-reduced fracture, for example, is able to transmit some of the compressive forces across the fracture plane. The implant, however, must substitute for the lost tensile properties across the fracture plane. This ability to share the load between the bone and the implant allows implant dimensions to be used on a much smaller scale than those necessary for a fully loaded situation (**Fig 1.5.5-2**).

The aim is therefore to use an implant system that provides sufficient stability for the fracture to heal in a predictable way but at the same time it adequately stabilizes the fracture preserving blood supply and reducing the associated morbidity of implant insertion. The current trend is to use more biologically-friendly fixation techniques where additional exposure would result in iatrogenic disturbance of blood supply. The hope is that a certain compromise on the mechanical side is compensated by a gain on the biological side by preserving vascular connection to the bony fragments. In addition, damage to associated structures such as nerves may be reduced by using minimally invasive techniques as opposed to large open procedures.

In case of reduced bone quality and quantity (defects, infection, atrophy, multifragmentation) the fixation device has to bear the majority if not all of the load. If sufficient bone is not present or healing does not progress in a satisfactory manner, further active intervention such as bone grafts may be required as even the largest plates will eventually fail in fatigue.

In some situations the bone fixation system must be able to bear the total load. Ideally, the majority of the load is borne by the fragments allowing the smallest fixation to be inserted. However, a range then exists whereby less support can be provided by the fragments due either to mechanical or biological conditions (eg, atrophy, defects). Then it becomes necessary for more load to be taken by the implant unit. In these cases the implant has to be of sufficient stiffness and strength to perform this function completely and we shift from a simple load sharing scenario, such as a simple linear fracture in the body of the mandible at one end of the spectrum, to a load bearing scenario such as a grossly comminuted or defect fracture at the other end of the spectrum (**Fig 1.5.5-3**).

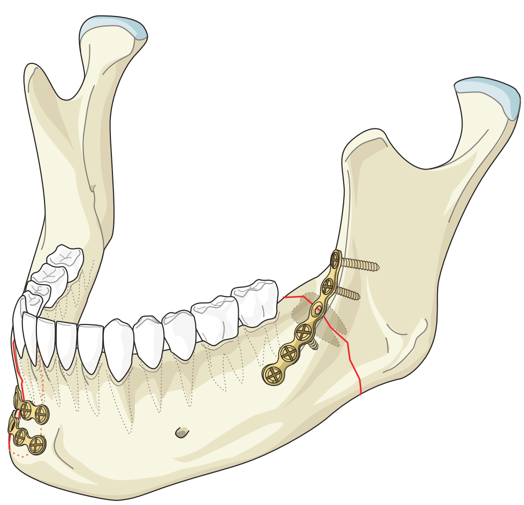

Fig 1.5.5-2 Miniplate fixation of the mandibular angle. Simple linear fracture. Load sharing osteosynthesis.

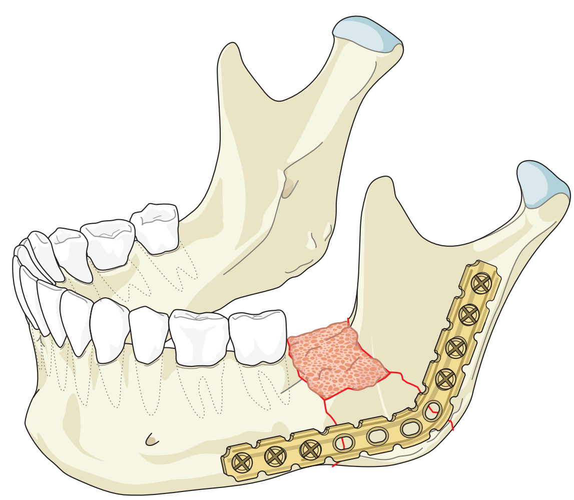

Fig 1.5.5-3 Reconstruction plate at the mandibular angle. Reduced buttress with bone defect. Load bearing osteosynthesis and bone graft.

Authors Adrian Sugar, Robert Bentley

The decision which implant to use is based on the surgeon's experience and the relative emphasis that he or she places on the relevant factors such as fracture type and dislocation and patient related factors. Fixation systems rarely fail if used appropriately. Failure is usually due to the surgeon not assessing the situation correctly and the underestimation of the loading conditions which exceed those required for the bone-implant unit to permit uninterrupted healing.

1.5.6 Principles of stabilization: splinting, adaptation, compression, lag screw principle

1	Splinting	95
2	Adaptation	95
3	Compression	96
4	Compression with a plate	97
5	Compression with lag screws	98
6	Compression with a plate in combination with a lag screw	100

Authors Adrian Sugar, Robert Bentley

1.5.6 Principles of stabilization: splinting, adaptation, compression, lag screw principle

1 Splinting

External splinting is the application of a device that reduces the mobility of bone fragments in one or both jaws. The fractured bones are not exposed and manipulated under direct vision, therefore this technique to treat fractures is also commonly called closed or indirect management.

External splinting in the craniomaxillofacial area may be applied internally to the teeth (in dentate patients) with arch bars, wires, or custom made splints. It may also be applied to the mucosa and underlying bone (for example in edentulous patients) by fixing a prosthesis or Gunning splint directly to one or both jaws. Devices for indirect fracture management can be applied directly to the bone transmucosally using IMF screws or similar devices, or transcutaneously using pins and an external fixator. Accurate fracture reduction is not always possible using these indirect methods of fixation and absolute stability of the fracture is rarely achieved. Provided that the reduction and stability are adequate and the mobility does not interfere with the healing process, these methods may be sufficient to achieve bony union if movement and forces on the fracture are minimized. However, external splinting is often an unreliable method of maintaining good fracture alignment while the bone unites.

The fixation of osteosynthesis implants directly to the fracture fragments after exposure and reduction is internal splinting. However, to avoid confusion with external splinting, the better terms are osteosynthesis or internal fixation. The internal splint may still allow some interfragmentary motion, but in general this tends to be less than with external splints. The degree of stability produced by osteosynthesis material in general varies considerably, from osteosynthesis with wire, to fairly flexible plates, and then more rigid devices.

2 Adaptation

In the application of internal fixation devices to a fracture, some brace the fragments together and others actually force the fracture edges into close approximation under pressure. Yet in the majority of uncomplicated simple fractures of the mandible and in most situations in the midface and cranium, the fixation device merely holds the fragments together after reduction without any attempt to apply forces to the fragments to compress them. Adaptation can be achieved with intraosseous wires or adaptation plate and screw combinations. The typical adaptation plate contains round holes allowing only central screw placement (**Fig 1.5.6-1a–b**). Locking

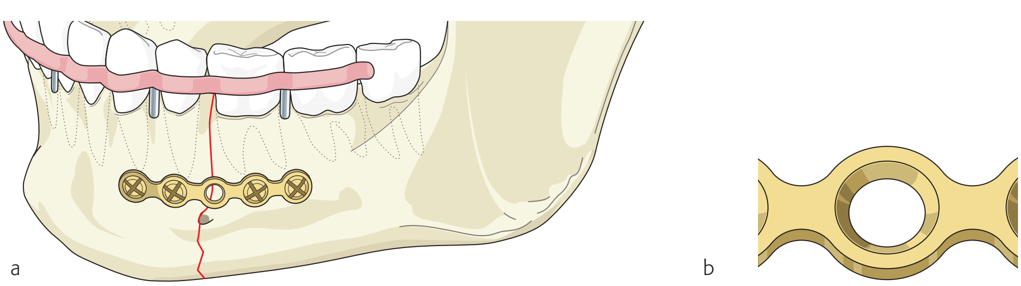

Fig 1.5.6-1a–b
a Fracture fixation of the lateral mandible with an adaptation plate. Load sharing situation.
b Close-up of the round hole of an adaptation plate.

plate and screw combinations are also typical adaptation plates. Adaptation plate osteosynthesis can be performed with microplates, miniplates, or stronger plates such as 2.4 reconstruction or Matrix mandible plates.

Adaptation osteosynthesis with wires has limited three-dimensional stability. For mandibular fractures, wire osteosynthesis is only indicated in combination with a period of mandibulomaxillary fixation (MMF). It also has defined drawbacks in midface fixation and is rarely used in modern fixation methods. Especially in dentate mandible areas, adaptation plates are usually fixed with monocortical screw anchorage. For monocortical screw placement, precise drilling in one direction is essential to maintain good screw-bone contact (**Fig 1.5.6-2**).

Today, adaptation plate osteosynthesis with micro-, mini- or stronger plates, (depending on the biomechanical situation), is the technique of choice for most craniomaxillofacial fractures.

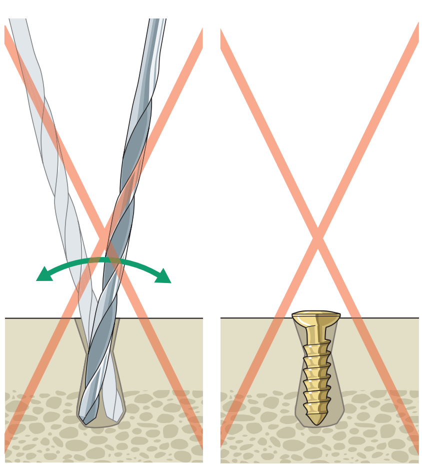

Fig 1.5.6-2 Unprecise drilling leads to a widening of a screw hole and results in undesired limited screw-bone contact.

3 Compression

Compression is a means of preventing interfragmentary movement by pressing two surfaces together. In a fractured bone, the effect is to increase interfragmentary friction and to preload the fracture. Compression permits undisturbed healing by guaranteeing stability even during function. It allows the sharing of load between the bone and the implants (plates and/or screws). Plates in this load sharing situation need not be as large and strong as those in a load bearing situation (eg, a mandibular resection defect) when the plates and screws have to support the entire load.

Compression is not a requirement for fixation of fractures of the craniomaxillofacial skeleton but is a method which, in the right circumstances, will increase stability and healing. Provided that the fragments are well reduced and held in direct approximation, compression osteosynthesis may permit primary (osteonal) bone healing in which osteons directly cross the fracture gap (**Fig 1.3.3-1b**, page 31). It is applicable in the mandible in simple, uncomminuted fractures only, and occasionally elsewhere in the facial skeleton. It is not applicable with a defect at the fracture, or when the bone ends are resorbed (eg, infection), nor usually in the maxilla where the bones are commonly too thin to support compression. Here adaptation osteosynthesis is appropriate.

Situations in which compression osteosynthesis may be considered are:
- Linear fractures of the mandible
- Zygomaticofrontal suture
- Root of the zygomatic arch
- Repositioning small fragments (with lag screws)
- Fixation of bone grafts (with lag screws)

Both plates and screws, and screws alone (see next section) may be used to achieve compression.

4 Compression with a plate

A compression plate is a plate with special oval-shaped holes which together with a screw forms the dynamic compression unit (DCU) (**Fig 1.4.3-8**, page 62). To allow for compression, it is necessary for the fractured bone ends to be well approximated before the implants are placed. Compression plates in general must be placed perpendicular to the fracture line.

Interfragmentary compression can be achieved by designing elliptical plate holes (as in a section of an inclined and horizontal cylinder), such that when the screw hole is drilled laterally (distant) from the fracture, the screw as it is inserted tries to achieve a more central position in the plate hole (**Fig 1.4.3-8**, page 62). The undersurface of the screw head is shaped in the cross-section of a ball which will move in the plate hole down the inclined plane of the angled cylinder. In doing so, it moves the bone–screw unit in the direction of the fracture line. When performed on both sides of the fracture, the compressive load is doubled. No more than one screw on each fracture side should be inserted in this way because the forces applied then may damage the bone. All other screws should be placed neutrally, ie, in the center of the plate hole (the part of the hole closest to the fracture line).

Compression plates are designed somewhat stronger and more rigid than adaptation plates as compression is only possible as long as the plate does not deform under the forces applied. Because of the resulting forces, bicortical screw insertion is mandatory in compression plate osteosynthesis. This creates a problem in the treatment of fractures in the lateral mandibular body. Due to the inferior alveolar canal and the tooth roots, compression plates may only be applied to the inferior border of the mandible. Consequently, when compression is applied on one side of a fracture, the opposite sides tend to open up. In case of the mandible these are the lingual side and the superior border. Opening of a lingual gap can be avoided by overbending the plate before it is fixed, and opening of a superior border gap by tension banding (**Fig 1.5.6-3a–c**). Tension banding can either

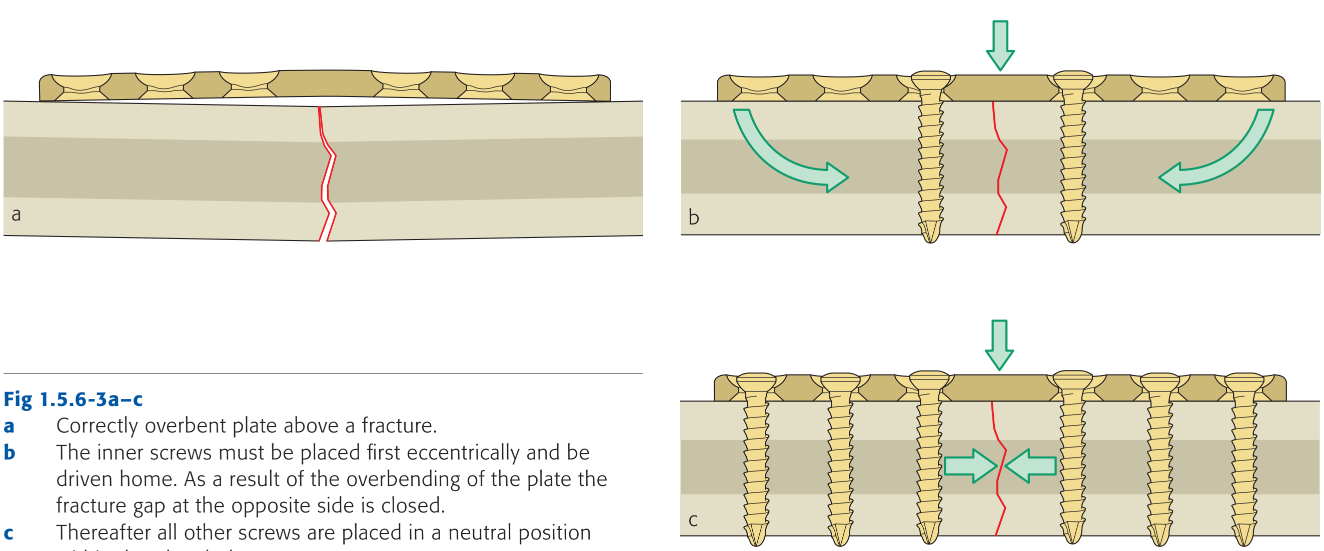

Fig 1.5.6-3a–c
a Correctly overbent plate above a fracture.
b The inner screws must be placed first eccentrically and be driven home. As a result of the overbending of the plate the fracture gap at the opposite side is closed.
c Thereafter all other screws are placed in a neutral position within the plate holes.

be performed with a tension band splint or a tension band plate, which is typically a monocortically fixed miniplate. Tension band splints or plates must be applied before the compression osteosynthesis is performed (**Fig 1.5.6-4a–b**).

Compression plating has little place in fracture treatment in the midface. Due to reduced buttressing capacity of the relatively thin midfacial bones, it may change the occlusion because of telescoping or cause bone necrosis at the fracture gap.

5 Compression with lag screws

Lag screw fixation is particularly applicable to any situation in which two broad flat surfaces need to be approximated. It therefore has particular application to:
- Oblique fractures
- Symphyseal fractures
- Fixation of bone grafts
- Sagittal split osteotomies

It has been shown that lag screw fixation of bone grafts produces better graft take and less graft resorption than most commonly used alternatives.

Some manufacturers have produced special lag screws. They are characterized by an unthreaded shaft, which is smooth and close to the head, while the tip is threaded. However any screw can be used in the lag screw technique. Most screws encountered in maxillofacial sets will be fully threaded.

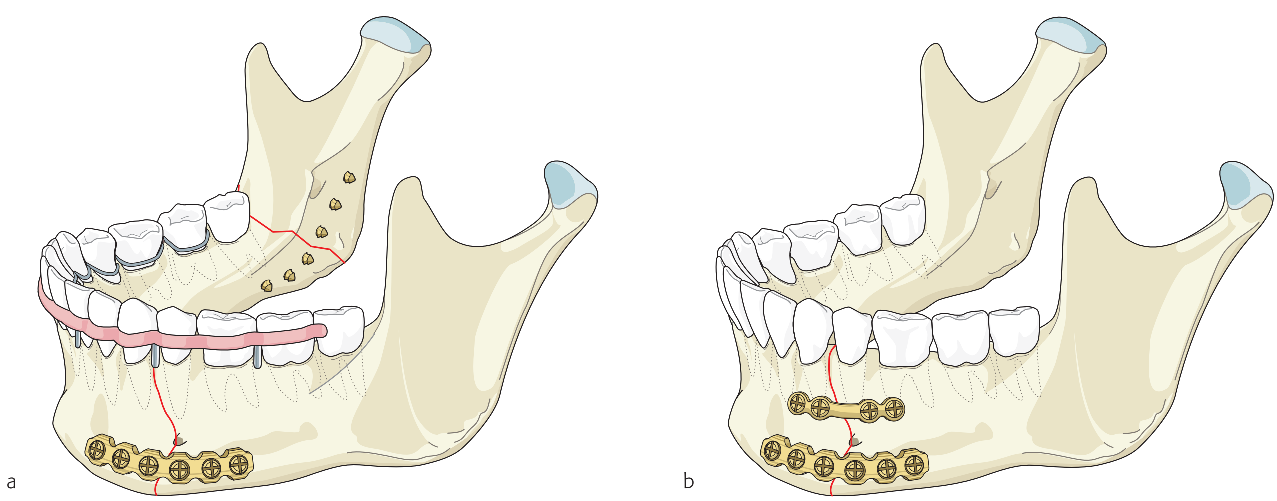

Fig 1.5.6-4a–b

a Tension banding performed with an arch bar reinforced with acrylic. In addition a universal fracture plate 2.4 is placed at the inferior border.

b Double-plate fixation with a miniplate as a tension band above the mandibular nerve, and a universal fracture plate 2.4 at the lower border of the mandible. Protection of the inferior alveolar nerve has to be considered.

In order to use a fully-threaded screw as a lag screw the proximal cortex of the bone must be drilled to a diameter as wide or wider than the width of the outer thread diameter. This is called a gliding hole because the screw will glide through it without gripping the bone. Into this gliding hole a special drill guide needs to be inserted, which then enables the distal cortex of the bone on the opposite side of the fracture to be centrally drilled to a diameter less than the width of the screw threads, typically the core diameter of the screw. This is called the threaded hole which the screw will grip as it is inserted. Depending on the situation (eg, how thick and strong the bone is) and the type of screw being used, this threaded hole may or may not be tapped before screw insertion. As the screw thread grips the distal threaded hole and the screw head engages the outer cortex adjacent to the gliding hole, the two fragments are squeezed together and interfragmentary compression results across the fracture. Lag screws always need to be placed exactly perpendicular to the fracture line to avoid secondary dislocation (**Fig 1.5.6-5**). If the cortex underlying the screw head is thick and strong enough, a countersink hole should be drilled to receive the screw head and prevent it becoming prominent and palpable. Countersinking allows for full contact between screw head and bone thus minimizing the risk of microfractures of the cortex, which otherwise may be seen in situations with minimal contact and subsequent overloading (**Fig 1.5.6-6a–b**). Care must be taken not to penetrate the cortex.

An alternative, though slightly less precise, way of inserting a lag screw is to drill all the way through both proximal and distal cortices of bone and then overdrill a gliding hole in the proximal cortex. This is less precise because the two holes are not necessarily centrally located and there is increased risk of drilling the gliding hole too deep.

If only one lag screw is inserted, the fragments can easily rotate making a reduction unstable. Therefore a minimum

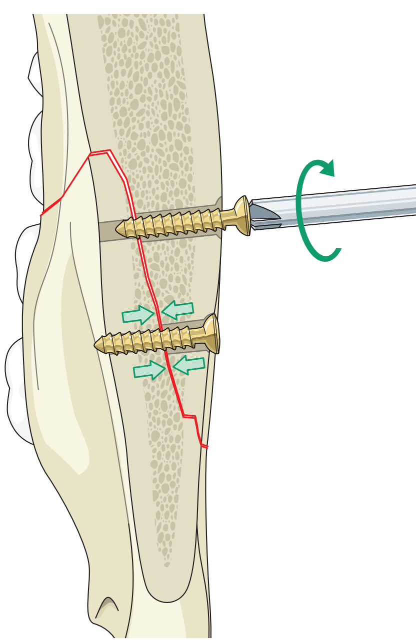

Fig 1.5.6-5 Interfragmentary compression exerted with two lag screws. Note: the outer holes are gliding holes which do not engage the thread, the inner holes are lag holes which engage the thread.

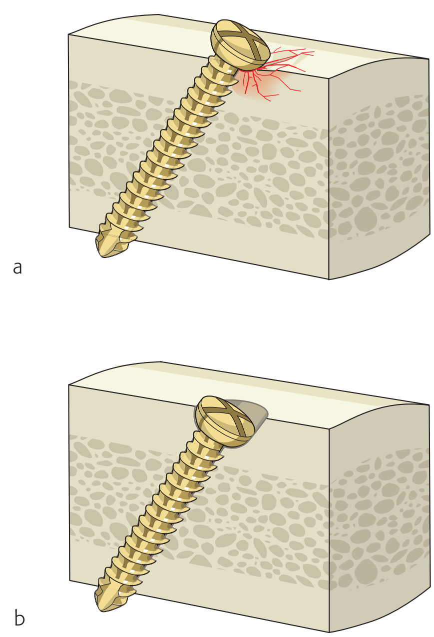

Fig 1.5.6-6a–b
- **a** Oblique insertion of a lag screw leads to a point-to-point eccentric force when the screw hits the bone and this may induce microfractures in the external cortex.
- **b** Countersinking leads to a full surface contact between screw and bone. The risk of microfractures is minimized.

of two lag screws should always be inserted. If only one screw can be inserted (as is sometimes possible, for example, at the root of the zygomatic arch), some other form of fixation should be used in addition (eg, a plate).

Interfragmentary compression across a sagittal split osteotomy may squeeze and thus damage the inferior alveolar nerve. It is also uncommon for the split surfaces of a sagittal split osteotomy to fit together completely and precisely in the new position of the mandible. Usually, there are areas of contact and areas of gap. Consequently, the use of interfragmentary compression across a gap usually displaces the fragments and thus disturbs the position of the occlusion and the condyle. As a result, the use of so-called position screws has become popular (**Fig 1.5.6-7**).

In order to place a position screw, a hole is drilled through both cortices which corresponds to the diameter of the screw shaft. The screw that is then inserted grips on both sides of the fracture and only holds the fragments in relative position to each other. It does not squeeze the fragments together, rotate, or move them.

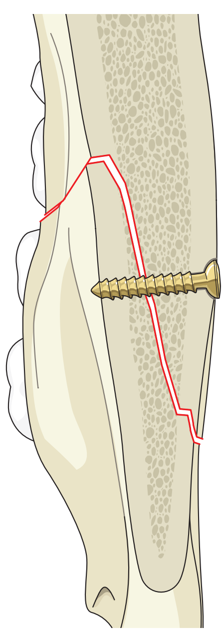

Fig 1.5.6-7 Fracture fixation with a position screw, this way the fracture or osteotomy gap is kept. Note: the inner and outer holes both engage the threads of the screw.

6 Compression with a plate in combination with a lag screw

Another way of achieving interfragmentary compression across a fracture is to use a screw which passes through the plate and then across the fracture (**Fig 1.5.6-8**). This screw has to be placed as a lag screw, so that the screw threads grip only the distal fragment and the head grips the proximal fragment, drawing the two together. When a lag screw is inserted through a plate in this way, all other screws in the plate need to be inserted secondarily and placed neutrally. This type of fixation is particularly applicable to oblique mandibular fractures.

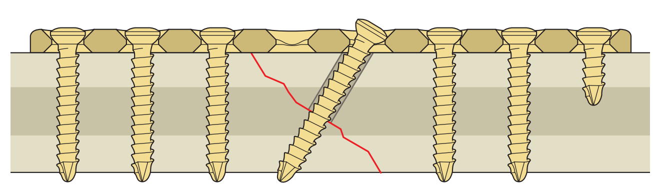

Fig 1.5.6-8 Compression with a lag screw and a plate. The lag screw must be placed first. Thereafter, the remaining screws must be placed in a neutral position.

1	Introduction	103
2	Tooth fracture	103
3	Tooth luxation	104
4	Tooth avulsion	105
5	Alveolar trauma	106
6	Primary dentition	107