
Editors: Johannes Kleinheinz, Christophe Meyer
Coordination: Michel Loose, Thomas Pfluger

Fractures of the Mandibular Condyle

Basic Considerations and Treatment



Foreword

To dedicate such a large volume to such a small bone—the mandibular condyle—may seem surprising. Without attempting to be encyclopedic, this book provides an overview of the techniques most commonly employed for the treatment of condylar neck and head fractures. They were described by the authors at the First International Symposium on Fractures of the Condyle, held on 29 and 30 November 2007 in Strasbourg, France.

The polemics surrounding the treatment of condylar fractures have been raging for some fifty years. It was Jean Delaire (Nantes, France) who launched the modern debate in 1960, noting the poor results of treatment in terms of articular function and physiology. Delaire recommended a method of functional treatment, or articular reeducation, which has since conquered France, Europe and, later, the world. The pertinence of his reflections and the clear improvement of functional outcome were evident. The functional treatment approach (with or without appliances) pioneered by Delaire remains the most widely used condylar fracture treatment in the world.

Surgical treatment has primarily focused on condylar neck fractures. Access to this small bone, which is deeply seated and covered by branches of the facial nerve, is considered to be very difficult. Courageous pioneers in the 1920s developed an access principle at a time when only pins and steel wires were available. The modern technique of compression screw osteosynthesis was first described by Petzel around 1980, and has since been improved, defended and publicized by Uwe Eckelt of Dresden, Germany in an ongoing crusade. I am also personally indebted to Uwe Eckelt, whom I visited in 1993, regarding the improvements I later developed to this technique. The modified technique permits osteosynthesis by a direct cutaneous approach, using a rectangular plate and, later, a trapezoidal plate subsequently developed by the engineers at Medartis in cooperation with Christophe Meyer, Besançon, France, in 2001. This much more direct method of osteosynthesis simplifies

the procedure and renders it more accessible to a greater number of persons.

The initially used endobuccal access route has always been very difficult. However, it still has many advocates, who currently use an endoscope for improved fracture visualization. This has led to the development of specific osteosynthesis materials, which will be described here by Constantin A. Landes (Frankfurt, Germany) and Günter Lauer (Dresden, Germany).

Up to the present, none of the available surgical techniques has become predominant. Some surgeons always remain unconvinced because the majority of techniques are still rather difficult to perform, the functional results are “sufficient” but not always excellent, and the risks of facial paralysis or obvious scarring are often dissuasive.

Nevertheless, the use of osteosynthesis has steadily progressed because anatomical reconstruction has undeniable advantages: early, pain-free and efficient reeducation and facial rehabilitation of better quality.

For most authors, fractures of the condylar head remain confined to the domain of functional reeducation. However, it has been demonstrated that shortening of the lateral pterygoid muscle irretrievably reduces its functional capacity. It is Michael Rasse (Innsbruck, Austria) who, from 1984 on, is credited with recommending osteosynthesis by a direct cutaneous access route to the articulation, achieving a functional outcome of excellent quality.

This book describes most of the techniques currently used for the treatment of condylar neck and head fractures. This review is complete but not exhaustive. The difficulty consists in offering a simple, reproducible and standardized technique which can one day help establish osteosynthesis of the mandibular condyles, which still has the reputation of being a particularly difficult surgery.

Professor Astrid Wilk, Department of Plastic, Oral and Maxillofacial Surgery, Strasbourg University Hospital, Strasbourg (France)

Preface

“The idea must become reality, or it will remain a soap bubble” (Berthold Auerbach). This book is the idea turned into reality originating from the International Symposium for Condylar Fracture Osteosynthesis which was organized by Professor Astrid Wilk in cooperation with the International Bone Research Association (IBRA) in Strasbourg in November 2007. We used the experience and expertise in treatment of condylar fractures which manifested there to compile this book.

This compendium comprises state-of-the-art knowledge, experience, statements and strategies regarding treatment of condylar fractures and was supplemented by basic research topics. It is thought as a support in individual decision-making in daily routine.

How long will this book be topical? Hopefully, a reprint will be necessary soon as this would prove the rapid progress in this field which can lead to new ideas materialising to the benefit of the patient and not turning into soap bubbles.

First of all, we would like to thank the authors who demonstrated their dedication and discipline in working out their contributions to the book and also patience when it came to amend the manuscripts. Furthermore, our special thanks go to our editorial colleagues Thomas Pfluger and Michel Loose for their help and support. On the part of the Quintessence Publishing Group we thank Mr. Bernd Burkart and Ms. Ina Steinbrück for their professional assistance.

Christophe Meyer and Johannes Kleinheinz, editors

Editors and Contributors

Me. Marie-Reine Bollack

Hôpitaux Universitaires de Strasbourg,
Service de Stomatologie Chirurgie Maxillo-Faciale
1 place de l'Hôpital, F-67091 Strasbourg Cedex, France

Prof. Pierre Bourjat

6 rue St. Florent, D-67200 Strasbourg, France

Dr. Luigi Califano

University of Naples Federico II, Department of
Maxillofacial Surgery
Via Pansini n° 5, I-80131 Napoli, Italy

Prof. Dr. Dr. Uwe Eckelt

Klinik und Poliklinik für Mund-, Kiefer- und Gesichts-
chirurgie, Universitätsklinikum der TU Dresden
Fetscherstr. 74, D-01309 Dresden, Germany

Prof. Edward Ellis III, DDS, MS

Division of Oral and Maxillofacial Surgery,
University of Texas Southwestern, Medical Center
5323 Harry Hines Blvd, CS3.104,
Dallas, TX 75390-9109, USA

Dr. Francesco Fabbrocino

University of Naples Federico II, Department
of Structural Engineering
Via Pansini n° 5, CI-80131 Napoli, Italy

Prof. Joël Ferri

Service de Chirurgie Maxillo-Faciale et Stomatologie,
Centre Hospitalier Régional Universitaire de Lille
F-59039 Lille Cedex, France

Dr. Wock Hallermann

Klinik und Poliklinik für Schädel-, Kiefer- und
Gesichtschirurgie Inselspital Universität Bern
CH-3010 Bern, Switzerland

PD Dr. Ariane Hohoff

Universitätsklinikum Münster, Poliklinik für
Kieferorthopädie
Waldeyerstr. 30, D-48149 Münster, Germany

Prof. Dr. Peter Hyckel

Friedrich-Schiller-Universität, Gesichtschirurgie/
Plastische Chirurgie
D-07740 Jena, Germany

Prof. Dr. Dr. Tateyuki Iizuka

Klinik und Poliklinik für Schädel-, Kiefer- und
Gesichtschirurgie, Inselspital, Universität Bern
CH-3010 Bern, Switzerland

Prof. Dr. Jean-Luc Kahn

Institut d'Anatomie Normale Faculté de Médecine
4 rue Kirschleger, F-67095 Strasbourg Cedex, France

Prof. Dr. Dr. Johannes Kleinheinz

Universitätsklinikum Münster
Waldeyerstrasse 30
D-48149 Münster, Germany

Univ. Doz. Dr. Clemens Klug

Medizinische Universität Wien, Universitätsklinik für
Mund-, Kiefer- und Gesichtschirurgie
Währinger Gürtel 18-20, A-1190 Wien, Austria

Dr. Dr. Constantin Landes

Zentrum der Zahn-, Mund- und Kieferheilkunde,
Johann Wolfgang Goethe Universität
Theodor-Stern-Kai 7,
D-60596 Frankfurt am Main, Germany

Prof. Dr. Dr. Günter Lauer

Klinik und Poliklinik für Mund-, Kiefer- und Gesichts-
chirurgie, Universitätsklinikum Carl Gustav Carus
Fetscherstr. 74, D-01307 Dresden, Germany

Dr. Olivier Lieger

Department Klinische Forschung, Inselspital
Postfach 43, CH-3010 Bern, Switzerland

Dr. Tim W. Lloyd

Eastman Dental Hospital, University College Hospital
235 Euston Road, NW1 2BU London, Great Britain

Dr. Maurizio Mattarocci

A. Cardarelli Hospital, Department of
Maxillofacial Surgery
Via A. Cardarelli 9, I-80131 Napoli, Italy

Prof. Christophe Meyer

Hôpital Jean Minjot, Service de stomatologie
et de chirurgie maxillo-faciale
Boulevard Fleming
F-25030 Besançon Cedex, France

Univ.-Prof. Dr. med. Dr. med. dent. Andreas Neff

Klinik und Poliklinik für Mund-, Kiefer-
und Gesichtschirurgie Standort Marburg
Georg-Voigt-Str. 3, D-35033 Marburg, Germany

Dr. Salvatore Parascandolo

A. Cardarelli Hospital, Department of
Maxillofacial Surgery
Via A. Cardarelli 9, I-80131 Napoli, Italy

Dr. Mario Pasquino

University of Naples Federico II, Department of
Structural Engineering
I-80131 Napoli, Italy

Dr. Gwenaël Raoul

Service de Chirurgie Maxillo-Faciale et Stomatologie,
Centre Hospitalier Régional Universitaire de Lille
F-59039 Lille Cedex, France

Univ.-Prof. Dr. Michael Rasse

Medizinische Universität Innsbruck
Christoph-Probst-Platz, Innrain 52
A-6020 Innsbruck, Austria

Prof. Dr. Dr. em. Dieter Schumann

Friedrich-Schiller-Universität
Bachstraße 18, D-07743 Jena, Germany

DI Dr. Rudolf Seemann

Medizinische Universität Wien, Universitätsklinik für
Mund-, Kiefer- und Gesichtschirurgie
Währinger Gürtel 18-20, A-1190 Wien, Austria

Dr. Eric Solyom

Service de Chirurgie Maxillo-Faciale et Stomatologie,
Centre Hospitalier Régional Universitaire de Lille
F-59039 Lille Cedex, France

Dr. Alessia Spinzia

University of Naples Federico II, Department
of Maxillofacial Surgery
Via Pansini n° 5, I-80131 Napoli

PD Dr. Thomas Stamm

Universitätsklinikum Münster, Poliklinik
für Kieferorthopädie
Waldeyerstr. 30, D-48149 Münster, Germany

Dr. Hanna Thorén MD, DDS, PhD

University of Helsinki Institute of Dentistry,
Department of Oral and Maxillofacial Surgery
Kasarmikatu 11-13, BOX 41
FIN-00014 University of Helsinki, Finland

Dr. Gaylord Throckmorton

Division of Oral and Maxillofacial Surgery,
University of Texas, Southwestern Medical Center
5323 Harry Hines Blvd, CS3.104, Dallas, TX 75390-9109

Prof. Dr. Dr. Arne Wagner

Praxis Prof. Arne Wagner
Solingergasse 5, A-1190 Wien, Austria

DDr. Felix Wanschitz

Medizinische Universität Wien, Universitätsklinik für
Mund-, Kiefer- und Gesichtschirurgie
Währinger Gürtel 18-20, A-1190 Wien, Austria

Prof. Dr. Dr. Dieter Weingart

Katharinenhospital, Klinik für Kiefer- und
Gesichtschirurgie
Kriegsbergstr. 60, D-70174 Stuttgart, Germany

Dr. Kai Wermker

Klinik und Poliklinik für Mund-, Kiefer-
und Gesichtschirurgie, Universitätsklinikum Münster
Waldeyerstr. 30, D-48149 Münster, Germany

Prof. Dr. Astrid Wilk

Hôpitaux Universitaires de Strasbourg,
Service de Stomatologie, Chirurgie Maxillo-Faciale
1 place de l'Hôpital, B.P. Nr. 426
F-67091 Strasbourg Cedex, France

Dr. Axel Wiss

Service de Chirurgie Maxillo-Faciale et Stomatologie,
Centre Hospitalier Régional Universitaire de Lille
F-59039 Lille Cedex, France

Table of Contents

Foreword V

Astrid Wilk

Preface VII

Johannes Kleinheinz, Christophe Meyer

Basics 1

1 Embryology, development and growth of the condyle 3

Michael Rasse

2 The temporomandibular joint 15

Jean-Luc Kahn

3 Physiology of the temporomandibular joint 21

Thomas Stamm

4 Incidence, etiology and classification of condylar fractures 29

Kai Wermker

5 History of treatment concepts 41

Uwe Eckelt

6 Biomechanics 47

Christophe Meyer

7 Clinical features of condylar fractures 65

Astrid Wilk

8 Imaging of condylar fractures 73

Pierre Bourjat

9 Microtrauma to the mandibular joint and condylar hyperplasia 81

Dieter Schumann, Peter Hyckel

10 Treatment of mandibular condylar process fractures: biological considerations 87

Edward Ellis, Gaylord Throckmorton, Olivier Lieger, Tim W. Lloyd

Functional treatment of condylar fractures 105

11 Orthopedic treatment 107

Ariane Hohoff

12 Functional treatment of condylar fractures 121

Joël Ferri, Gwenaël Raoul, Axel Wiss, Eric Solyom

	Surgical treatment of condylar neck fractures	131
13	Surgical approaches to the condylar neck	133
13.1	The transparotideal approach	135
	<i>Dieter Weingart</i>	
13.2	Low submandibular/periangular approach	139
	<i>Uwe Eckelt</i>	
13.3	High perimandibular approach / modified Risdon – Strasbourg approach	143
	<i>Astrid Wilk</i>	
13.4	Retromandibular approach	155
	<i>Johannes Kleinheinz</i>	
14	Open reduction without internal fixation	161
	<i>Tateyuki Iizuka, Wock Hallermann</i>	
15	Open reduction, internal fixation (ORIF)	167
15.1	Two-plate fixation	169
	<i>Salvatore Parascandolo, Alessia Spinzia, Maurizio Mattarocci, Francesco Fabbrocino, Mario Pasquino, Luigi Califano</i>	
15.2	MODUS Trilock five- or six-hole 1.5 plate technique	175
	<i>Rudolf Seemann, Arne Wagner, Felix Wanschitz, Clemens Klug</i>	
15.3	Lag screw fixation	179
	<i>Uwe Eckelt</i>	
15.4	The TCP plating technique	185
	<i>Christophe Meyer</i>	
15.5	Delta Plate technique	195
	<i>Günter Lauer</i>	
15.6	Surgical treatment of condylar neck fractures with four-hole MODUS TriLock plates	199
	<i>Andreas Neff</i>	
15.7	Surgical treatment of condylar neck and head fractures: Resorbable systems	205
	<i>Constantin A. Landes</i>	

	Surgical treatment of condylar head fractures	221
16	Surgical approaches to the condylar head	223
16.1	Temporoauricular approach	225
	<i>Michael Rasse</i>	
16.2	Retroauricular approach	231
	<i>Andreas Neff</i>	
17	Internal fixation of the condylar head	239
	<i>Andreas Neff</i>	
	Special topics	247
18	Endoscopic open reduction and internal fixation of condylar fractures	249
	<i>Günter Lauer</i>	
19	Pediatric condylar fractures	257
	<i>Hanna Thorén</i>	
20	Postoperative physiotherapy after condylar fracture surgery	267
	<i>Marie-Reine Bollack</i>	
	Conclusion	274
	<i>Johannes Kleinheinz, Christophe Meyer</i>	

Embryology, development and growth of the condyle

Michael Rasse

Clinic of Craniomaxillofacial and Oral Surgery, Medical University, Innsbruck, Austria

Phylogenesis

Mammals differ from reptiles, amphibians and fish in that they developed a new jaw articulation. During the course of evolution, the primary jaw articulation of non-mammalian vertebrates was replaced by a secondary jaw articulation. Studies suggest that the primary jaw joint was incorporated in the chain of ossicles of the middle ear. The primary jaw joint is composed of bones derived from the skeleton of the branchial arches, as are other parts of the hearing apparatus. The skeleton of the branchial arches is derived from preformed cartilage that either remains as cartilage, undergoes ossification, or disappears during ontogenesis.^{9,31} In higher and primitive vertebrates, parts of the jaws are also derived from bones of desmal origin. The number of bones that form the cranium and the jaws generally decreases over the course of phylogenesis.^{9,31,56}

Aphetohyoidea

The Aphetohyoidea, a class of fish-like animals, were the most primitive jaw-bearing vertebrates (Fig. 1.1). They became extinct during Permian era as they were not included in the mainstream of evolution that led to the development of Chondrichthyes, Osteichthyes and Tetrapoda.³¹ The segmented head and gill (branchial) region is divided into four to six branchial arches, the skeleton of which is divided into pharyngobranchial, epibranchial, ceratobranchial and basibranchial (copula) components (Figs. 1.2, 1.3). The general terminology used to denote the individual parts of the branchial arches may vary in different types of branchial arches and in different species. In addition, some species do not have all branchial arch elements. The arch of the jaws of Aphetohyoidea consisted of a two-part palatoquadrate corresponding to the epibranchial and the mandibular segment, corresponding to the ceratobranchial cartilage (i.e., Meckel's cartilage in mammals). The skeleton of the jaw was bony and not connected to the calvarial skeleton, which consisted of four to six circumorbital bones and numerous small plates of desmal bones.

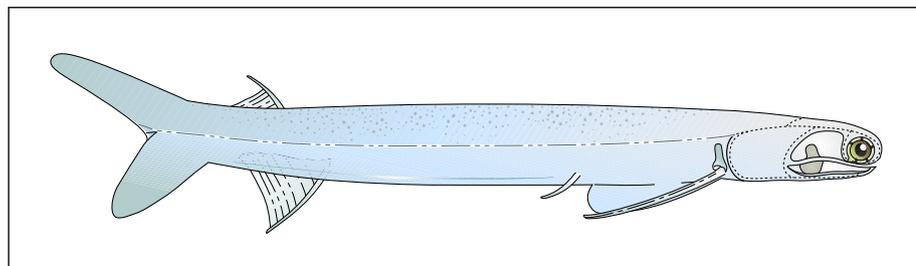


Fig. 1.1 *Acanthodes* sp.
(after D.M.S. Watson, 1937).

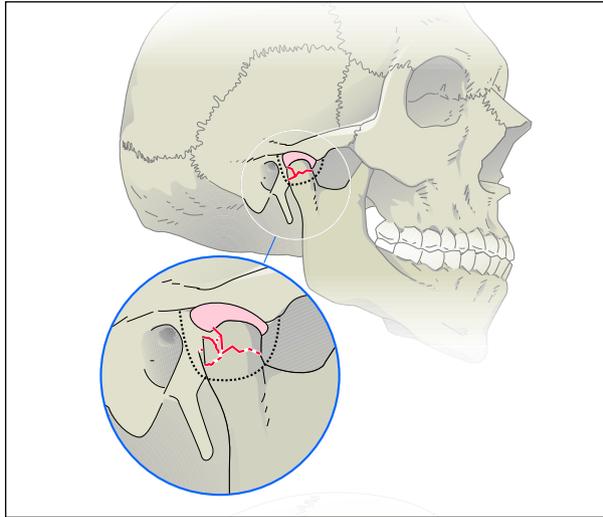
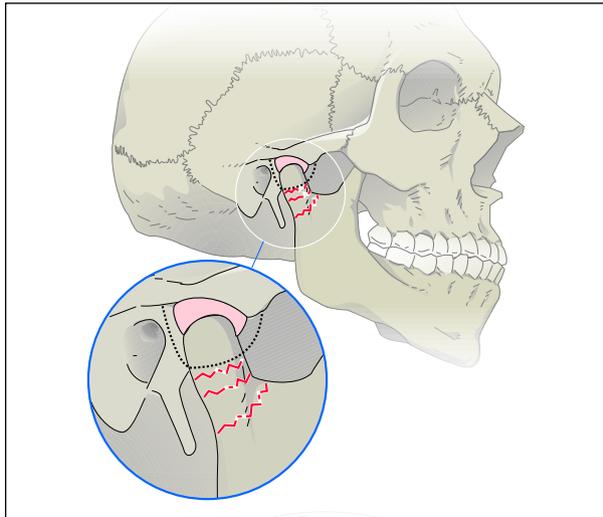
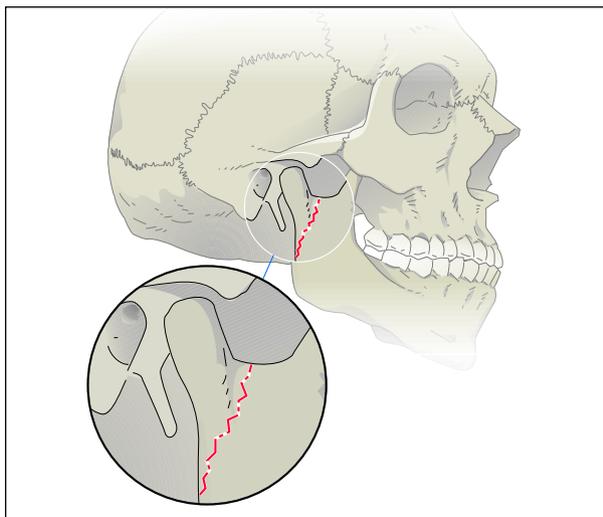


Fig. 4.3 Classification of condylar fractures according to anatomical fracture level.
a Intracapsular condylar head fracture



b High, middle-high and low fracture of the condylar neck



c Subcondylar fracture (fracture of the condylar base)

- Type IV, low condylar neck fracture with dislocation i.e. luxation
- Type V, high condylar neck fracture with dislocation
- Type VI, intracapsular fracture of the condylar head/condyloid process

Lindahl²³ proposed a quite complex classification based on fracture level, deviation/displacement, and position of the condylar head in relation to the fossa:

- 1, Fracture level:
 - 1a, condylar head (Fig. 4.3a);
 - 1b, condylar neck (Fig. 4.3b);
 - 1c, subcondylar/condylar base (Fig. 4.3c)
- 2, Deviation and displacement:
 - 2a, bending/deviation with medial overlapping of fragments;
 - 2b, bending/deviation with lateral overlapping of fragments;
 - 2c, bending/displacement without overlapping;
 - 2d, undisplaced fissural fracture without deviation
- 3, Relation between condylar head and fossa:
 - 3a, no dislocation;
 - 3b, slight dislocation;
 - 3c, moderate dislocation;
 - 3d, severe/complete dislocation/luxation
- 4, Condylar head fractures:
 - 4a, horizontal;
 - 4b, vertical;
 - 4c, impacted/compression fracture

In accordance with several other authors, Lindahl describes the subcondylar fracture line as starting at the sigmoid notch and extending to the posterior border of the mandible. A condylar neck fracture is located at the small and thin part of the condylar process below the condylar head. Lindahl defines a condylar head fracture as a fracture located at or above the level of the insertion of the condylar capsule; in other words, most or all of the fracture is intracapsular.²³

In 1997, Krenkel proposed the following classification based on objective measurement criteria.¹⁹

- High condylar neck fracture: fracture located within the upper quarter or upper third of the mandibular ramus
- Intermediate condylar neck fracture: fracture located within the upper third or upper half of the mandibular ramus

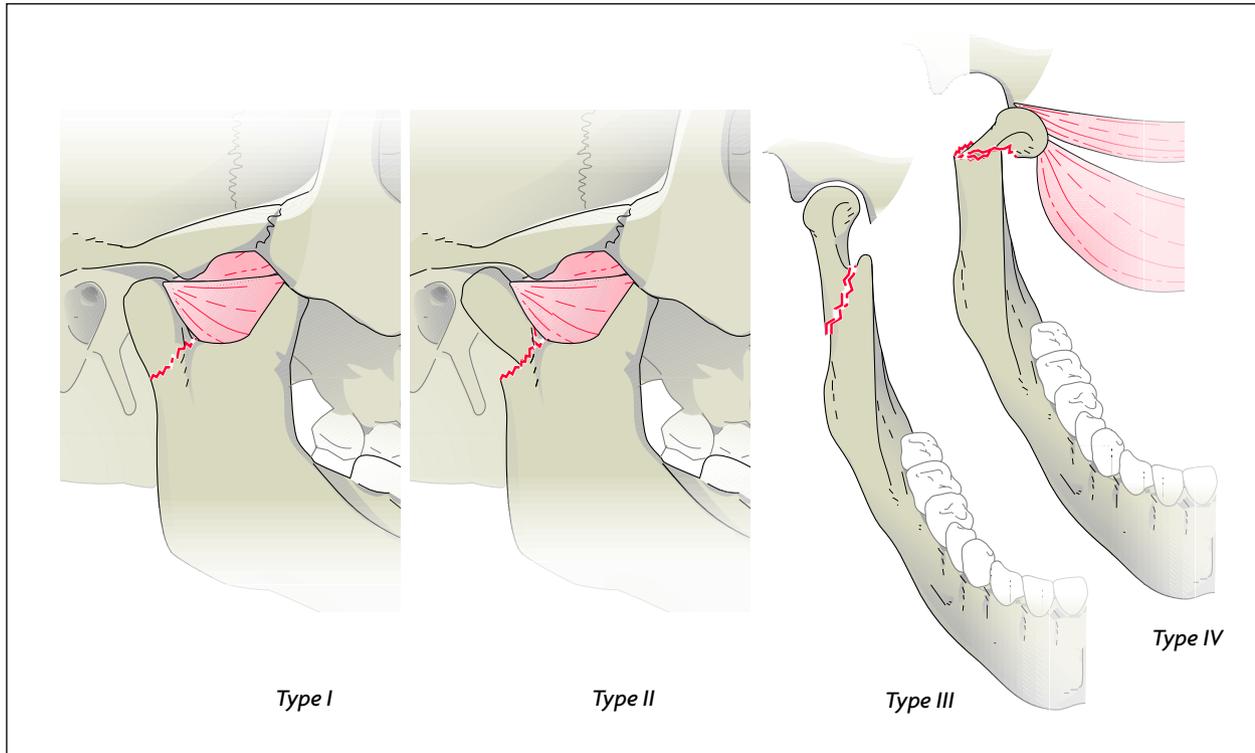


Fig. 4.4 Classification of condylar fractures according to Spiessl and Schroll (see text for explanation).

- Low condylar neck fracture: fracture located between the lower half of the mandibular ramus and the mandibular angle

Note: The third type frequently is not classified as a condylar fracture, but as a simple fracture of the mandibular ramus.

Ellis et al. classified condylar fractures as follows:¹¹

- Condylar head fracture: an intracapsular fracture located at the border between the condylar head and neck (Fig. 4.3 a)
- Condylar neck fracture: fracture located below the condylar head but on or above the lowest point of the sigmoid notch
- Condylar base fracture: fracture in which the fracture line is located below the lowest point of the sigmoid notch

They also differentiated between

- No detectable dislocation on X-rays and correct position of the condylar head
- Slight dislocation in which most of the condylar head remains within the articular fossa and the degree of angulation/bending of the condylar process is $< 20^\circ$
- Severe/maximum dislocation: the condylar head is positioned on the articular tubercle or more anteriorly, and the degree of angulation/bending is $> 20^\circ$

Neff et al.²⁸ extended the classification of Spiessl and Schroll⁴⁰ and discriminated type V and VI diacapitular fractures of the condylar head/condyloid process into the following types:

- Type A (VI A): displacement of the medial parts of the condylar head; the vertical dimension is intact without contraction and the fracture is restrained/supported
- Type B (VI B): fracture involving the lateral parts of the condyle with a loss of vertical dimension, a lack of restraint, contracted fracture appearance, and involvement of the lateral pole of the condylar head and lateral ligament

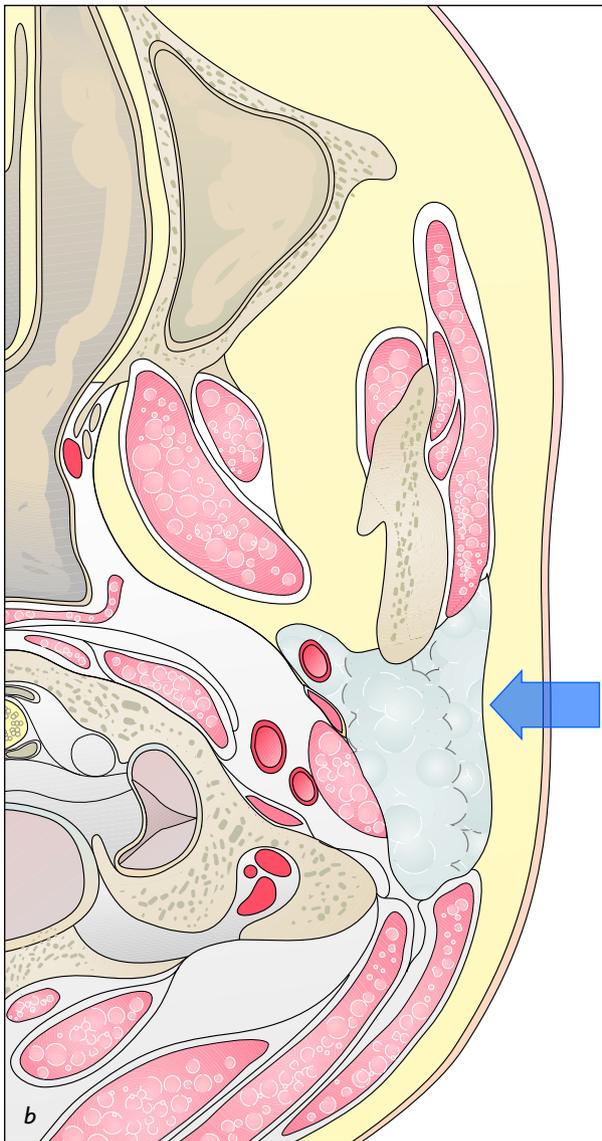


Fig. 13.61 a and b The incision line lies between the sternocleidomastoid muscle and the ascending mandibular ramus.

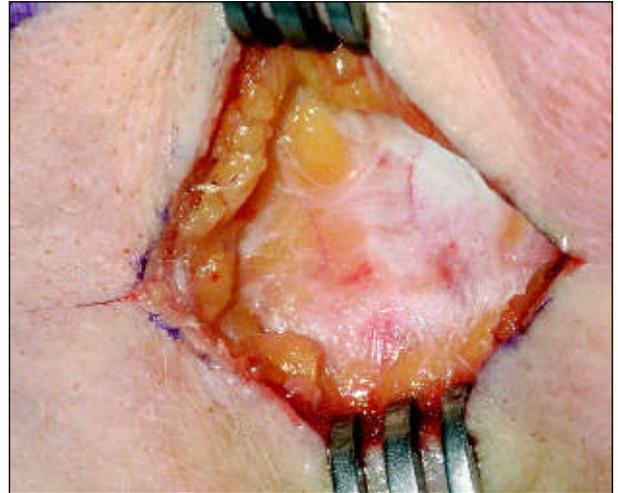


Fig. 13.62 Capsule of the parotid gland

adjustment can be facilitated by pulling the mandible downwards. After aligning the fragment, stable plate or screw osteosynthesis is carried out (Fig. 13.66). The posterior border of the ramus and the mandibular notch serve as reference lines for correct three-dimensional repositioning.

Wound closure is performed in layers after checking mandibular mobility and dental occlusion. A wound drain (suction drain) is inserted close to the fracture line, with the exit placed at the lower border of the incision line. The first step is refixation of the pterygomasseteric sling, followed by closure of the subcutaneous and cutaneous layers. The skin sutures are removed one week later. After completion of wound healing, the scar is hardly visible (Fig. 13.67).

Comparison with other approaches

The retromandibular approach differs from other approaches in that the parotid gland is bypassed dorsally along anatomical structures without a need for dissection of any additional tissues or organs. With this approach, the incision is more cranial than in a submandibular approach and more dorsal than in a transparotid approach. At this point, it is important to remember the basic difference between incision and dissection. A retromandibular incision has also been used for the transparotid approach.^{5,7} This must be taken into account when different approaches are compared, especially in regard to complication rates.

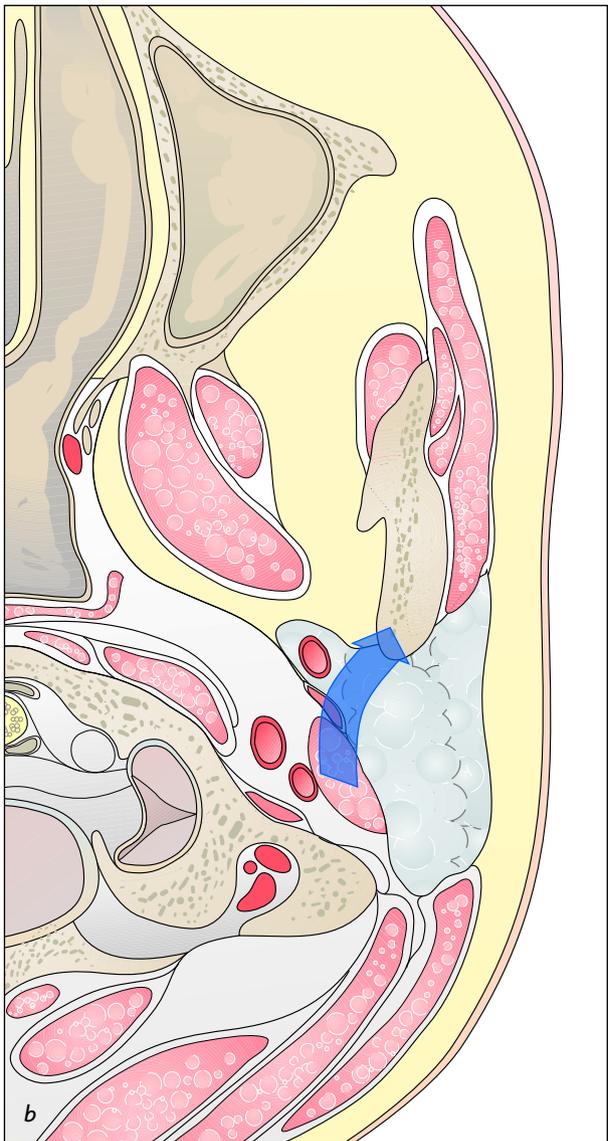
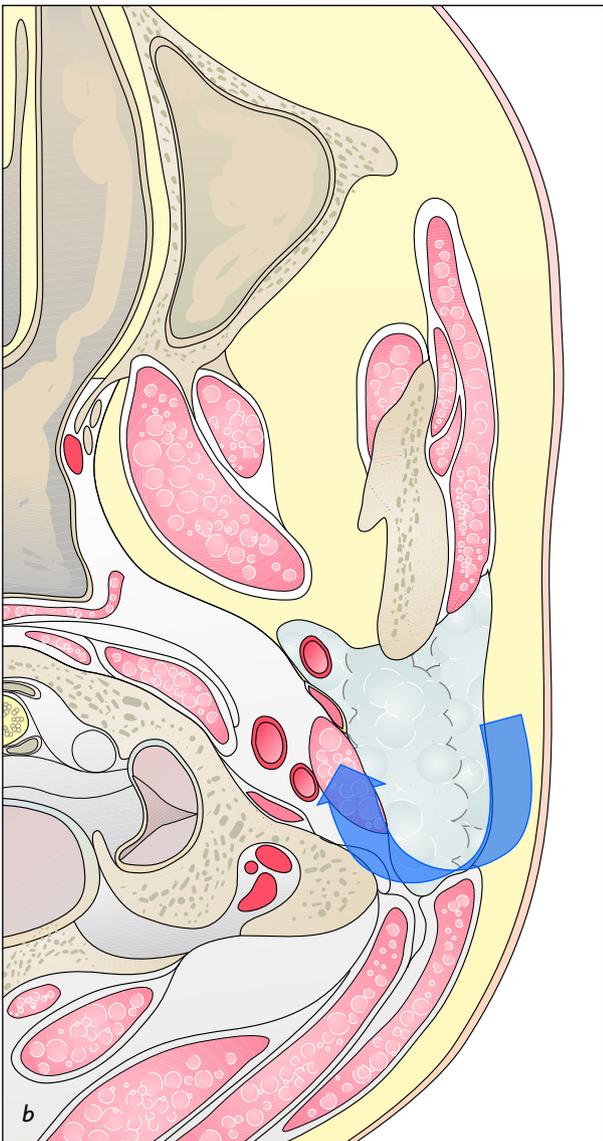
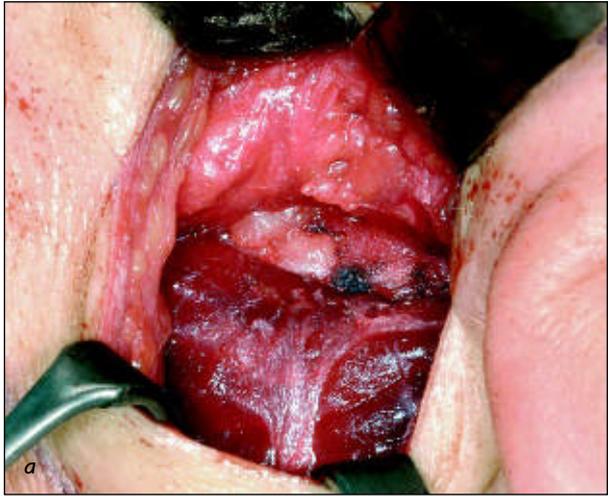
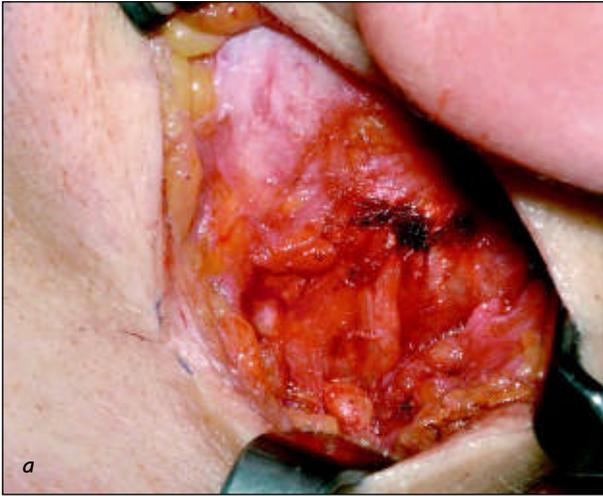


Fig. 13.63 a and b The parotid gland, sternocleidomastoid muscle and angular tract are exposed after dorsally directed dissection on the capsular surface of the gland.

Fig. 13.64 a and b The dissection around the parotid gland exposes the mandibular angle.