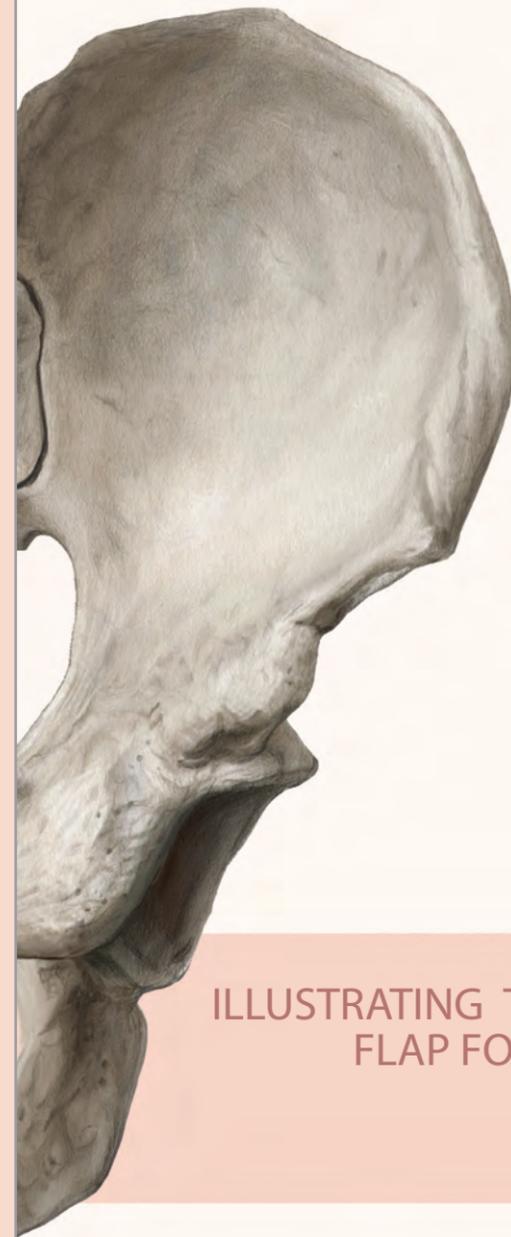


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ILLUSTRATING THE VASCULARISED, SKELETONISED ILIAC BONE FLAP FOR OROMANDIBULAR RECONSTRUCTION

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Thesis Master Scientific Illustration

Dirk Traufelder

Maastricht 2015

# Table of Content

Preface		p. 5
1	Introduction	p. 6
	Project	p. 6
	Target group	p. 6
	Goal	p. 7
	Preparation	p. 7
	Motivation	p. 7
2	Anatomy	p. 8
2.1	The iliac crest	p. 9
	<i>Drawing Technique Figures 1-2</i>	p. 11
	<i>Drawing Technique Figures 3-10</i>	p. 17
2.2	The mandible	p. 18
	<i>Drawing Technique Figures 11-12</i>	p. 19
3	The iliac crest in comparison	p. 22
	<i>Drawing Technique Figures 14-15</i>	p. 24
4	The surgery	p. 26
4.1	The preoperative computer assisted planning	p. 27
4.2	The bone flap harvesting	p. 28
	<i>Drawing Technique Figures 17-27</i>	p. 34
	<i>Drawing Technique Figure 28</i>	p. 36
Conclusion		p. 38
Zusammenfassung		p. 39
Acknowledgement		p. 40
Bibliography		p. 40



## Preface

My first contact with the Master Scientific Illustration was during my Bachelor's course in Stage and Costume Design at the Maastricht Theatre Academy in 2005. Here, I had the opportunity to join the weekly life drawing classes given by Professor Jacques Spee, head of the department Scientific Illustration in those years.

As a stage and costume designer, I discuss and interpret human habitats and outer appearances in relation to social, emotional, historical and dramatic aspects in order to support actors in their endeavours to convey human life in all its facets.

Drawing the human physiognomy is an important tool for me to reveal and communicate my own interpretations to directors, actors and within workshops in an effective way. Accurate illustrations as a way to communicate complex information became very appealing to me and as a student of the Master of Scientific Illustration in 2009, I got the chance to focus on this aspect of my two-dimensional work.

During this highly specialised programme, which is a collaboration between the Faculty of Arts at Zuyd University of Applied Science and the Faculty of Health, Medicine and Life Sciences at Maastricht University, I developed my drawing skills in different techniques and dissected anatomical specimens in order to depict the uncovered structures. Moreover, I attended and illustrated surgical procedures. By doing this, I extended my field of work, which was contentually influenced by aspects of architecture, interior design, fashion, history, art and psychology, by the inner structure of the human body and its physiology and anatomy.

Hence, I transferred my illustration skills from backstage right into the spotlight of my current professional platform.

# 1

## Introduction

### Project

When I was looking for a challenging project for my Masterthesis, Rogier Trompert and Dr Andreas Herrler introduced me to Professor Dr Andreas Prescher, head of the Prosector of Anatomy Department of the University Hospital RWTH Aachen, and we discussed my work and a possible cooperation. He and the scientific team around PD Dr Alireza Ghassemi, an Oral and Maxillofacial surgeon, have been working on the vascularised iliac bone flap for bony reconstruction in the head and the neck region, with the main focus on its supplying blood vessels and its shape and dimensions. Scientific illustration could play an important role to make the complex information accessible and I was very pleased by PD Ghassemi and Professor Prescher's proposal to involve me in that project.

As to its length, width and natural contour, the iliac bone crest is one of the most valuable regions for harvesting bone flaps for microvascular reconstruction. The bony defect can result from trauma, tumour resection or can be congenital and can involve the upper and the lower jaw. Unfortunately, some disadvantages made the iliac bone flap less popular compared to the fibula flap during the last decades. The short pedicle and unreliable vascularisation of the soft tissue can be mentioned in this regard. To harvest vascularised bone graft from the iliac crest and to avoid donor site morbidity, profound knowledge of its main supplying vessel, the deep circumflex iliac artery (DCIA), and its neighbouring structures is required. Consequently, it is often harvested with a bigger amount of surrounding soft tissue to insure the survival of the flap. This procedure often leads to a much more bulky and for facial reconstruction unsuitable flap compared to the fibula free flap, which may increase the donor site morbidity.

Nevertheless, if the surgeon can carefully differentiate and consequently reduce the size of the flap, he can avoid abdominal hernia, peritoneal perforation as well as nerve and arterial injuries. Therefore, PD Ghassemi developed a unique approach to skeletonise this flap. This method offers the superior bone quality of the iliac crest and enables the use of donor sites such as latissimus dorsi or upper leg, if an osteomusculocutaneous flap is needed. On the other hand, it eliminates the mentioned disadvantages of the previous method.

In January 2013, the research team around PD Ghassemi proposed and published a new and more complete classification of the relevant supplying vessels. It is based on bilateral dissections of the iliac regions in 78 cadavers and anatomical findings of 60 clinical cases. They recently compared and evaluated all previous publications on this topic to extract and conclude the up to date situation. In addition, they currently examine the expected anastomoses of the DCIA and its posterior counterpart, the iliolumbar artery, in the hope to find more specific information about the perimeter of the disposable vascularised bone.

The main topics of my illustration work arising thereby are the different subtypes of the supplying vessels of the iliac crest in relation to their neighbouring structures, the benefits of the iliac crest towards the fibula and the transplantation technique applied by PD Ghassemi. As a 3D mapping, it can guide the surgeon during the harvesting time and also can be used as teaching tool for learning surgeons and students.

## Target group

The target group of my illustration work consists of reconstructive surgeons in education and audiences of scientific congresses interested in PD Ghassemi's work. Accordingly, my illustrations ought to be readable, highly specialised and anatomically precise in all details. Since the basic anatomy is well-known by the surgeons, I can reduce the depicted anatomy to a minimum.

## Goal

With this documentation, I aim to summarise and support all aspects of my Thesis in a constructive, condensed and uniform manner. I want to depict the variations of the deep and superficial iliac artery and vein more accurately and realistically than it was done two years ago. I intend to improve the understanding of the topic. Also, I aim to facilitate the differentiation and the comparability of the subtypes with actual surgical situations. As a result, my work could be useful during preoperative computer assisted planning, flap harvesting intraoperatively and teaching purpose.

Furthermore, I want to evolve my own abilities in my field of work as a professional scientific illustrator, especially through close cooperation with a specialist, who gives me valuable insights into various working processes of a scientific research team.

## Preparation

During our first appointment, PD Ghassemi provided me with more than 30 publications concerning the iliac bone flap for oromandibular and oromaxillofacial reconstruction since its introduction by Ian Taylor et al. in the early 1970s. Different approaches were developed since then, including both vascularised and nonvascularised grafts from the iliac crest but also the fibula, the scapula and the ribs. The ribs were already harvested since the early 1920s. These

approaches were documented in several long-term studies and case studies. A few classifications were introduced and illustrated in various ways but none of those are as extensive and complete as the one developed by Ghassemi et al. (2013).

Furthermore, I studied the general anatomy of the hip and the jaw using anatomical atlases, models and as well fixated as non-fixated specimens in the institute of prosectorship at the University Hospital RWTH Aachen. I also attended the surgical procedure performed by PD Ghassemi at the Teaching Hospital "Klinikum Bremerhaven-Reinkenheide" and developed the first illustration-list in close consultation with my mentor, Rogier Trompert, and PD Ghassemi.

## Motivation

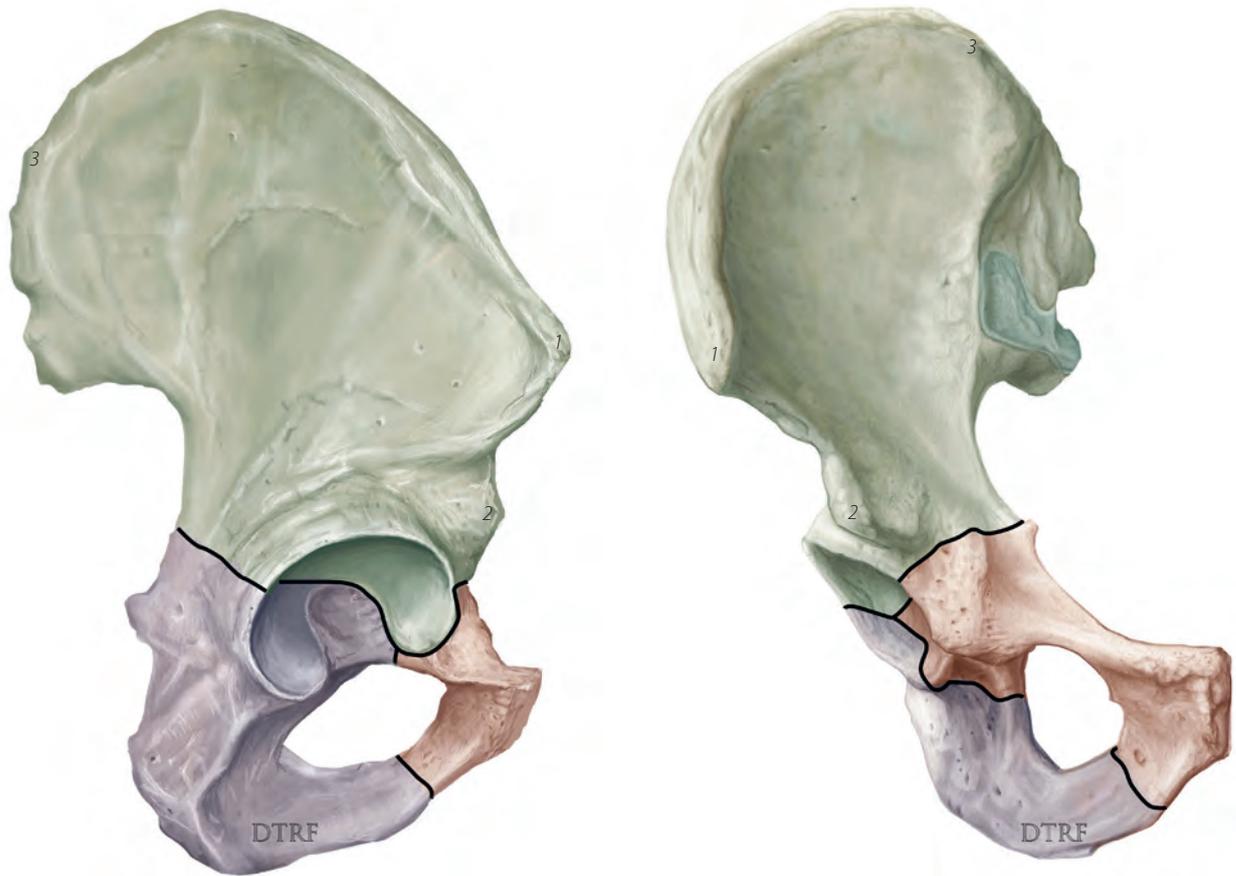
Oromandibular reconstruction is one of the most challenging procedures for reconstructive surgeons. The approach has to be highly individualised for each patient to avoid donor site morbidity and to facilitate dental restoration. On the practical side, it should prevent salivary incontinence and should give maximal ability to speak, swallow and masticate. For the aesthetic part, it should achieve the most pleasing cosmetic result possible.

The face with its exposed position plays an important role for social acceptance and interaction. Bad results confront the patient with various problems of physical and psychological nature. Because the reconstruction is crucial for recovery, research on the most usable skeletal part, the iliac crest, and the related surgical procedures, has to be developed as far as possible.

These aspects make my Master Thesis a very fascinating project to me. With this project, I may help surgeons to optimise their approach. Additionally, I highly appreciate to be part of a current research with clinical implications, which gives my work an extra dimension.

# 2

## Anatomy



**Figure 1**  
Coxal bone from lateral and ventral view

ILIUM	<span style="display:inline-block; width:20px; height:10px; background-color:#8ebf8e;"></span>
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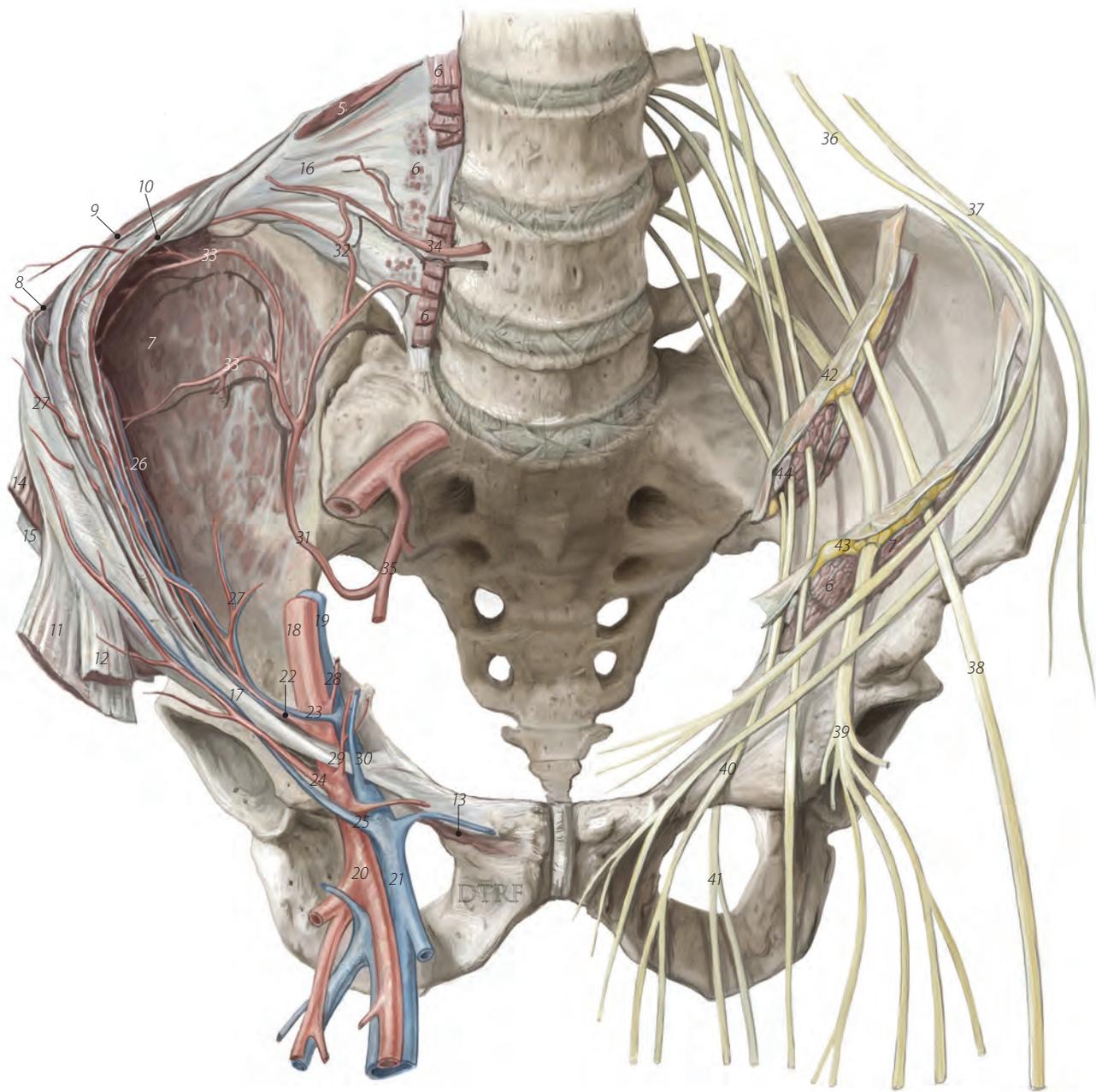
## 2.1 The iliac crest

The iliac crest is the superolateral margin of the greater pelvis and the uppermost edge of the ilium, the largest of the three fused bones of the hip, namely the ilium, the ischium and the pubis (fig. 1).

It reaches from the anterior superior iliac spine (ASIS) in a sinuous-shaped course to the posterior superior iliac spine (PSIS) and divides into three portions right behind the ASIS, the external and internal lip and the intermediate zone, which lies in between. It is slightly narrowed in the centre and wider at its outer parts but finds its widest part approximately 5 cm behind the ASIS, where the outer lip bulges laterally into the iliac tubercle.

The iliac crest is palpable through its entire length and therefore one of the most important skeletal landmarks of the human body. It helps to identify the dividing line between the abdomen and the pelvis on the one hand and the L4 vertebra to perform lumbar punctures on the other.

The iliac crest is used as a source for bone marrow cells and stem cells for bone marrow transplant procedures as it contains a high amount of red bone marrow and is considered safer to use than the vertebrae in the spine.



**Figure 2**  
 Pelvis from ventral view, including relevant vessels, muscles and nerves

## **Drawing Technique Figures 1-2**

*For the illustrations concerned with the anatomy, I combined a pencil drawing technique with alternate digital editing. First, I chose to draw a complete pelvis in ventral view, which formed a solid foundation for any further step. Then, I reconstructed the structures involved with the help of anatomy books and specimens and added slices of cross-sections to clarify the position of the nerves in relation to the muscles, the pre-peritoneal fat and the peritoneum.*

*I started with analogue pencil sketches, digitalised them, made a digital greyscale colouration, printed it in black and white on drawing paper, finished the shading and all details with pencil, digitalised the finished pencil drawing again and made the final polychrome colouration in Adobe Photoshop.*

*This process may be unusual, but has the following advantages. To print a smooth shaded delineation on clean paper with fresh and receptive pores can lead to a precise, sharp and highly detailed pencil drawing in considerably less time than without an underlying print. Furthermore, the quality, precision, details and analogue charisma of the pencil drawing can be transmitted into colour by means of digital colouration. So, it can be done directly and more efficiently in comparison to traditional watercolour or coloured pencil techniques. Following the same principles as watercolour and its use of transparent layers, the complete drawing can be used as a monochrome underpainting. It can be painted and edited in separate layers and can be changed in colour, saturation, contrast and layer order. The tools used are based on different analogue techniques.*

*Additionally, there can be zoomed into the picture. As it is detached from its original dimensions, it can be sharpened more and more if necessary.*

*Subsequently, this technique combines digital efficiency with an analogue touch. It underlines and expresses my experiences with human specimens in a quite fitting manner. Looking inside a human body is anything but clean and it was my goal in these illustrations to find a way in between the readability of a clean illustration and reality.*

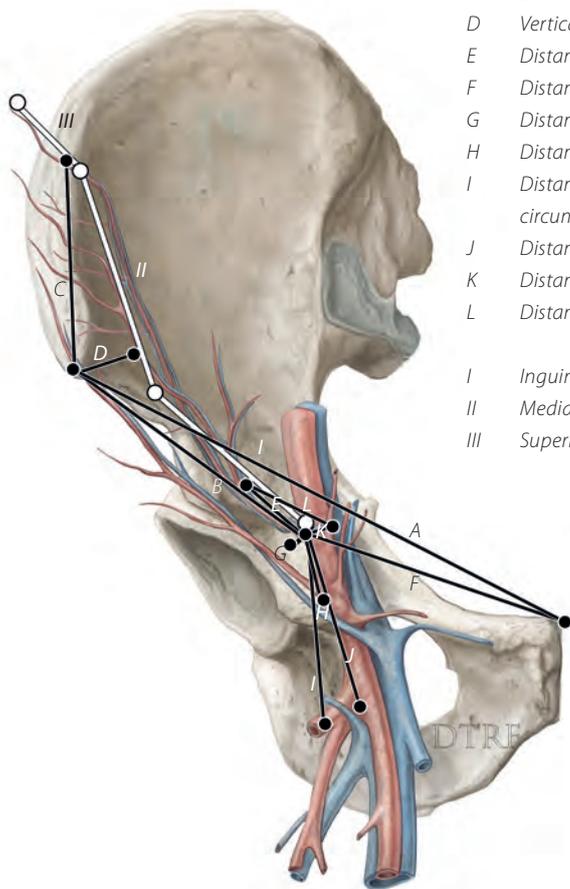
Many muscles and fasciae of the thigh and trunk are attached to the iliac crest and the ilium (fig. 2). The iliac crest supports these muscles and fasciae as well as the flat and widely shaped ilium, which protects the delicate organs. Thus, the main function of the iliac crest is stabilisation.

The external oblique muscle, the latissimus dorsi and the fascia lata are connected to the outer lip of the iliac crest, while the internal oblique attaches to its intermediate zone. Moreover, the transverse abdominis muscle, the quadratus lumborum muscle, the iliolumbar ligament and the iliac muscle, as well as the iliacus fascia and the transversalis fascia originate from the inner lip of the iliac crest.

The anterior superior iliac spine gives rise to the tensor fasciae latae, the sartorius muscle and the inguinal ligament. The anterior inferior iliac spine attaches the straight head of the rectus femoris muscle and the iliofemoral ligament (not shown in fig. 2). The gluteal muscles of the buttock are attached to the lateral side of the ilium.

As already mentioned, the nourishing vessels of the iliac crest are highly variable in appearance.

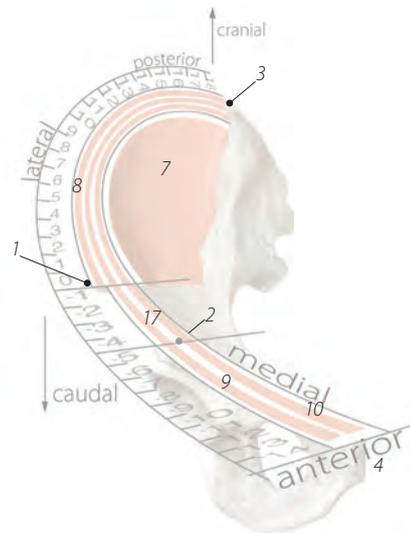
The most important blood supply is insured by the deep circumflex iliac artery and its accompanying vein, the deep circumflex iliac vein (DCIV), which both originate from the external iliac artery (EIA) close to the inguinal ligament. The DCIA mostly consists of two main branches, the horizontal branch (HB) and the ascending branch (AB). The horizontal branch can be divided into three different parts, the inguinal segment, the medial to crest segment, and the superior to crest segment (fig. 3). The ascending branch mostly arises from the inguinal segment of the horizontal branch and is the most dominant branch of up to four muscular branches. It perforates the transverse abdominis muscle and runs upwards between the transverse abdominis and the internal oblique muscle in both cranial and posterior direction. It sends out several musculocutaneous branches in between and anastomoses with the inferior epigastric artery on the one hand and the iliolumbar artery on the other.



**Measurements of relevant Landmarks (in cm)**

		Mean	Prototype
A	Distance from the ASIS to the pubic symphysis	14,52	13,40
B	Distance from the ASIS to the origin of the DCIA	7,09	7,20
C	Distance from the ASIS to the crossing point of the DCIA with the iliac crest	5,79	7,00
D	Vertical distance from the ASIS to the HB	1,40	1,50
E	Distance from the origin of the DCIA to the origin of the AB	2,46	2,20
F	Distance from the origin of the DCIA to the pubic symphysis	7,08	6,20
G	Distance from the origin of the DCIA to the inguinal ligament	1,21	0,20
H	Distance from the origin of the DCIA to the origin of the SCIA	1,94	1,70
I	Distance from the origin of the DCIA to the origin of the lateral femoral circumflex artery	5,48	3,60
J	Distance from the origin of the DCIA to the division of the femoral artery	4,56	3,75
K	Distance from the origin of the DCIA to the origin of the DCIV	1,12	1,00
L	Distance of the origin of the DCIV to the branching point	2,15	2,00

- I Inguinal segment
- II Medial to crest segment
- III Superior to crest segment



**Figure 3**  
Coxal bone from lateral view, including relevant vessels and landmarks

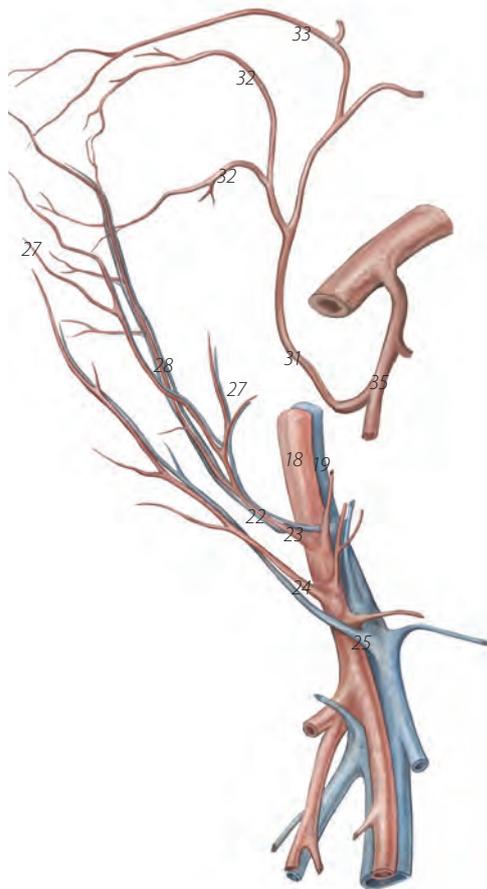
**Figure 4**  
Cartesian coordinate system transferred to the coxal bone

The medial to crest segment describes the part of the horizontal branch from the ASIS to the union line off the transversalis fascia and the iliacus fascia. It runs close to and approximately 2 cm inferior to the inner lip of the iliac crest and gives off two to eight osteomusculocutaneous branches. These branches perforate the iliac muscle and enter the cortex of the iliac crest in order to nourish it and its overlaying skin.

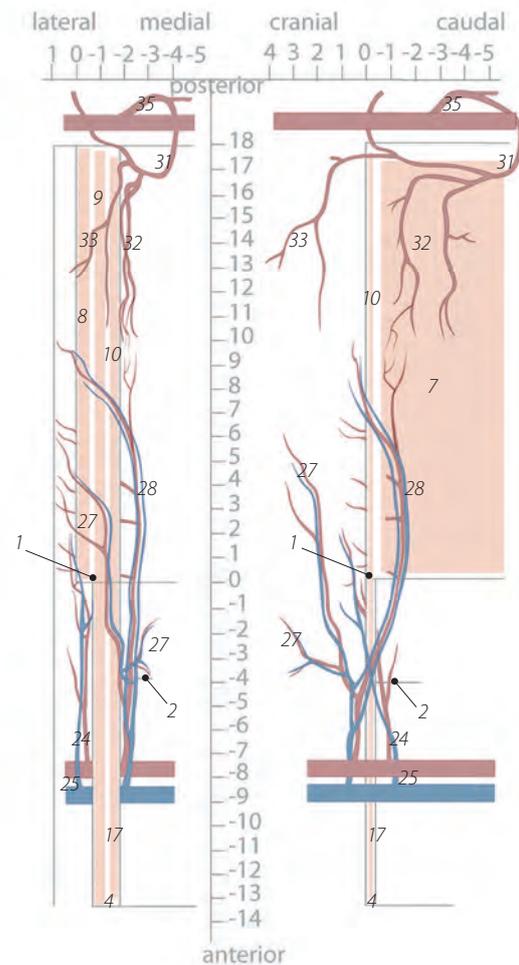
The third part of the horizontal branch is a terminal musculocutaneous perforator, which pierces the union line of the transversalis fascia and iliacus fascia to enter the abdominal musculature superior to the iliac crest and to

fan out on its overlaying skin.

The superficial circumflex iliac artery (SCIA) and vein (SCIV) originate more caudally, from the femoral artery and vein. The two latter are the elongations of the external iliac artery and vein. They mainly nourish the muscles of the upper leg and partly the iliac crest. During the first examinations of free groin flaps during the early 1970, the SCIA has been considered as the main vascular lifeline of the iliac crest, which led to higher donor site morbidity. Ian Taylor first described the DCIA as the main blood supply of the iliac crest in 1979.



**Figure 5**  
Relevant vessels as prototype



**Figure 6**  
Prototype transferred to a Cartesian coordinate system (in cm)

**Subtypes Figures 7-10**

- Type 1 DCIA is showing one AB and one HB, SCIA is showing one branch
- Type 2 DCIA is showing two or more HB
- Type 3 DCIA is showing two HB, whereof one originates from the EIA
- Type 4 DCIA is showing two or more AB
- Type 5 DCIA is showing two AB, the HB is short and returning
- Type 6 DCIA is showing one dominant AB
- Type 7 DCIA is showing one early AB
- Type 8 DCIA is showing one late AB
- Type 9 AB originates from EIA
- Type 10 DCIA originates from epigastric artery
- Type 11 AB originates from epigastric artery, HB originates from the EIA

- Type 12 SCIA is showing no branches
- Type 13 SCIA is showing 2 branches
- Type 14 SCIA originates from the DCIA
- Type 15 SCIA originates caudal to the bifurcation
- Type 16 DCIV originates superior to the EIA
- Type 17 DCIV originates inferior to the EIA
- Type 18 DCIV anastomoses with the SCIV
- Type 19 Lateral cutaneous femoral nerve passes the iliac crest cranial to the ASIS
- Type 20 Lateral cutaneous femoral nerve passes the iliac crest caudal to the ASIS

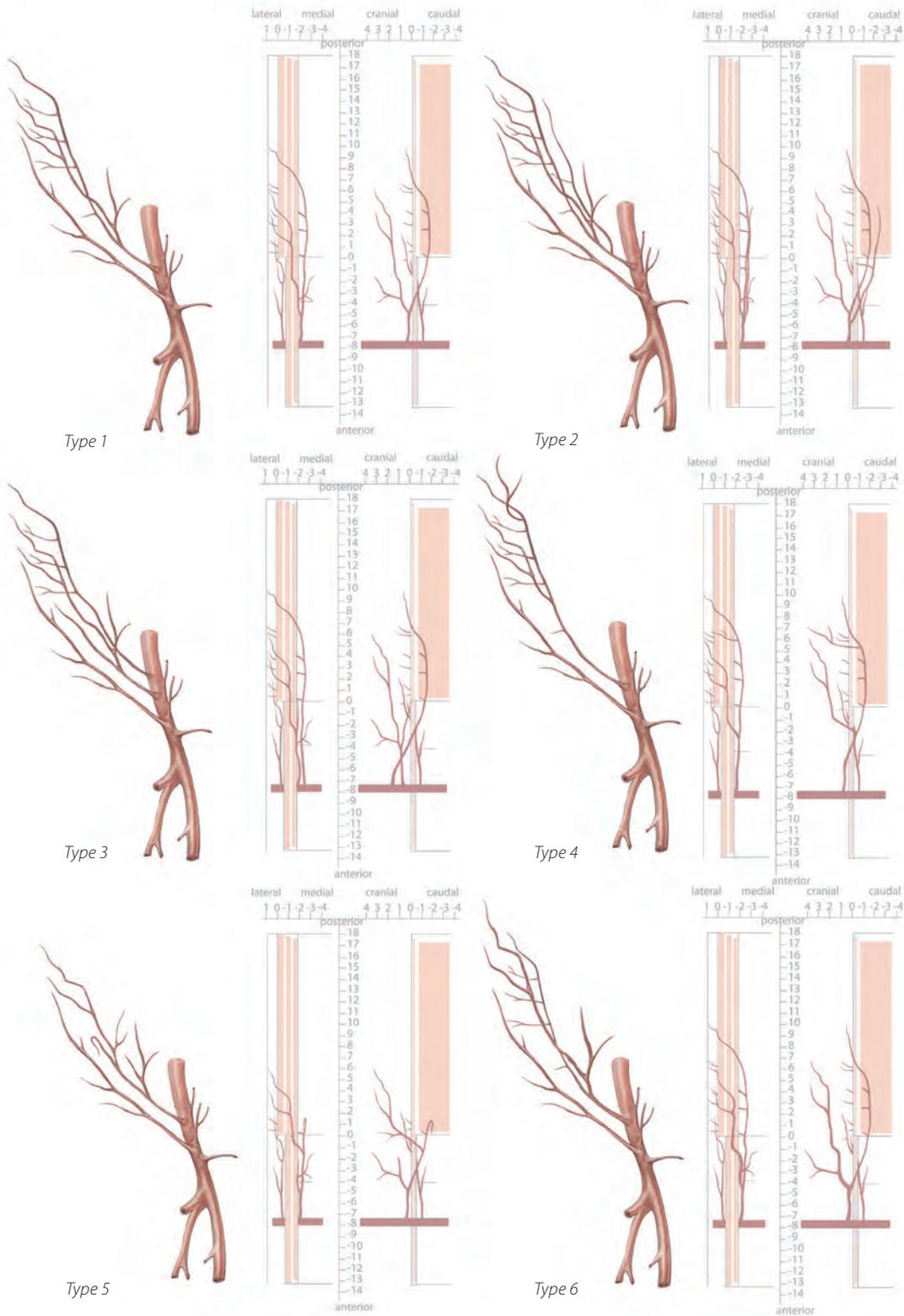
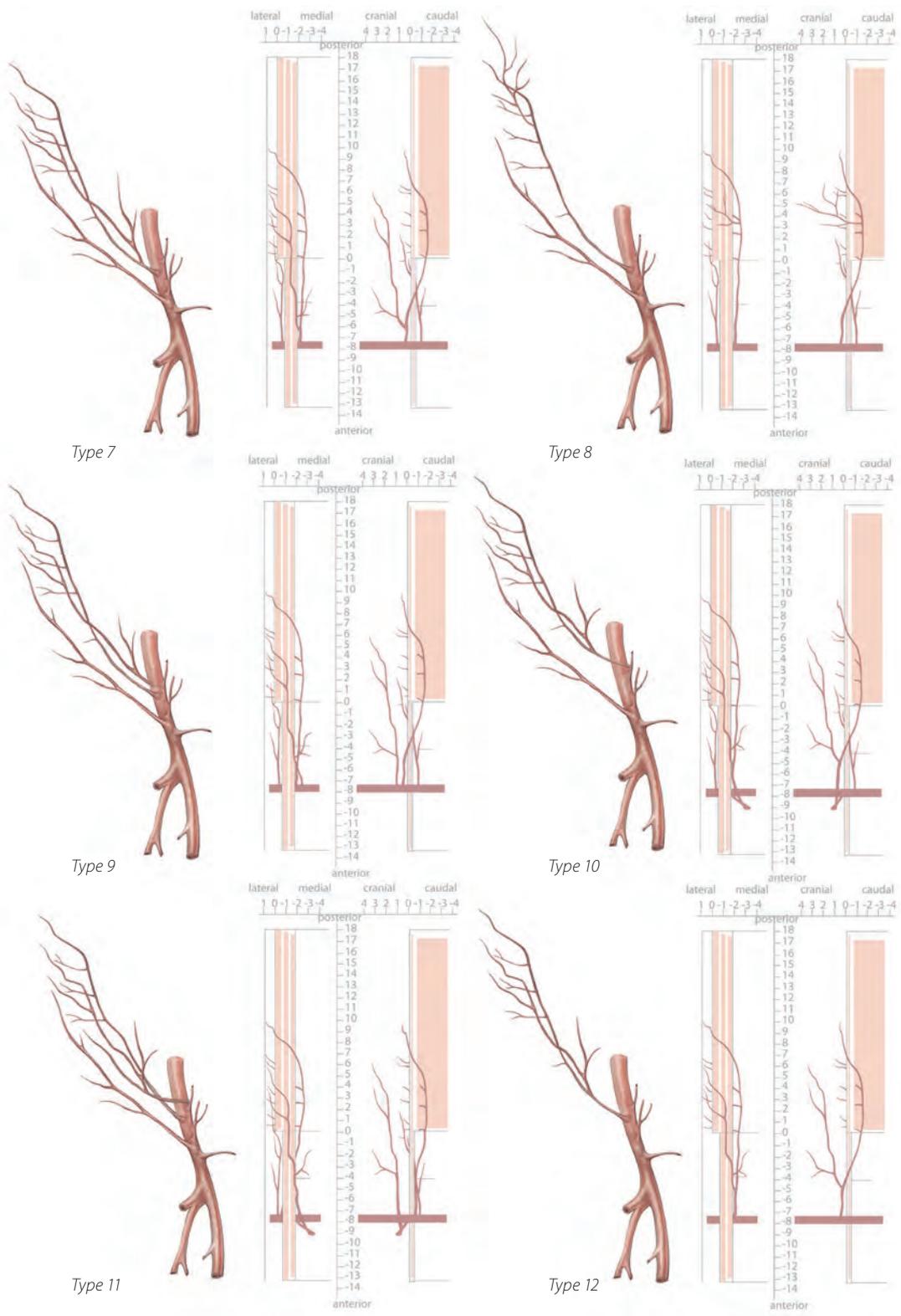


Figure 7 Subtypes 1-6



Type 7

Type 8

Type 9

Type 10

Type 11

Type 12

Figure 8 Subtypes 7-12

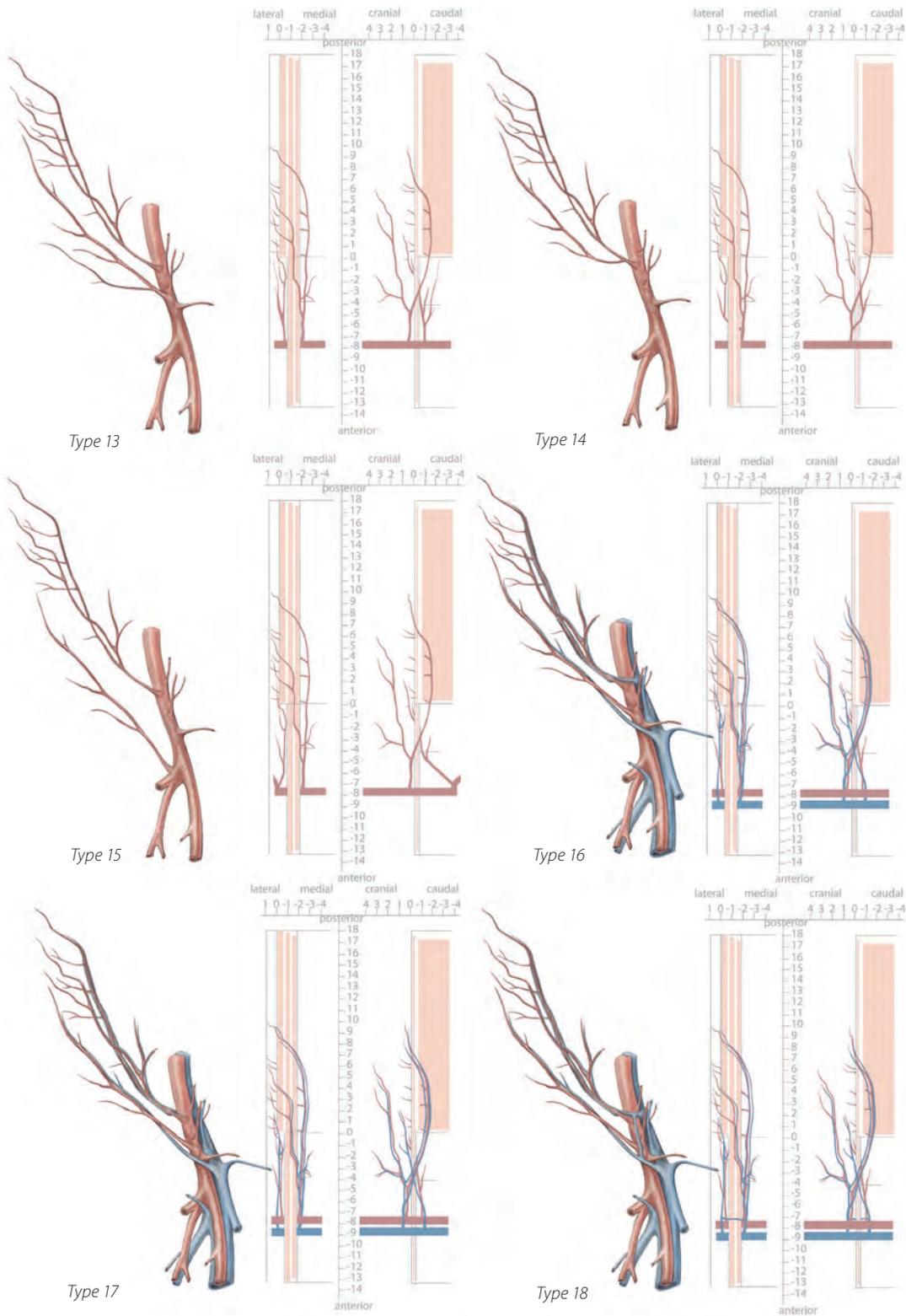
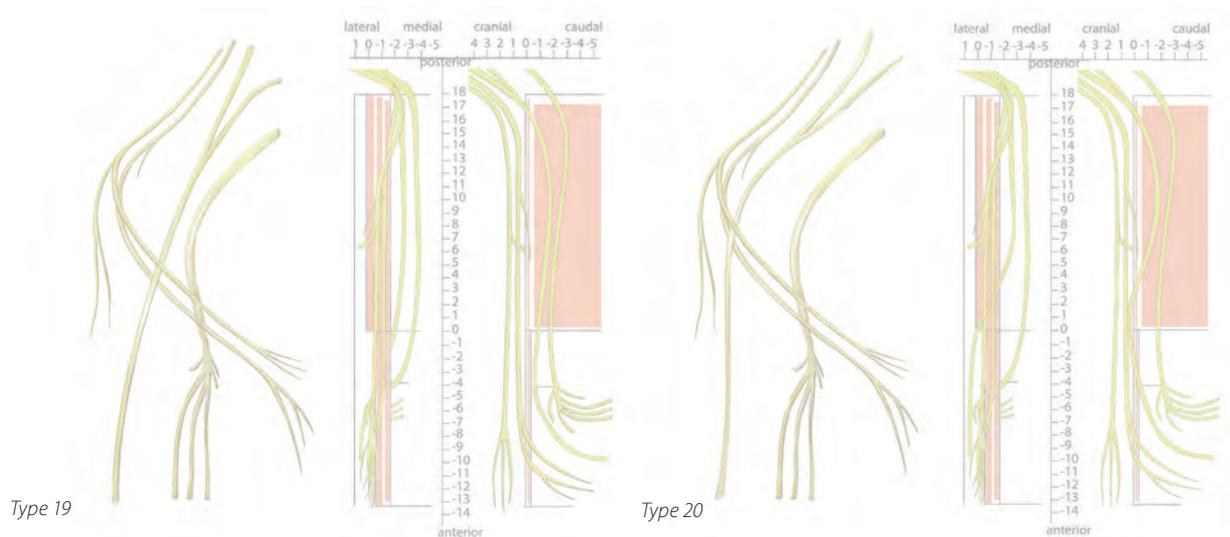


Figure 9 Subtypes 13-18



**Figure 10** Subtypes 19-20

Three nerves of the lumbar plexus cross the surgical site, whereof two variations appear (fig. 2).

The femoral nerve can pass the external iliac artery inferior or superior to the preperitoneal fat and consequently may lie right underneath the blood vessels dissected by the surgeon. Also, the lateral cutaneous femoral nerve sometimes departs from his ordinary course anterior to the ASIS to go right across the iliac spine in posterior position to it (fig. 10). Third, the inguinal nerve has to be taken in account, which usually perforates the transversus abdominis muscle close to the anterior part of the iliac crest and finally runs through the inguinal canal.

### **Drawing Technique Figures 3-10**

To give an overview of the twenty different subtypes, these are fifteen different subtypes concerning the DCIA and SCIA, three concerning the DCIV and two the *N. cutaneus femoris lateralis*, I combined realistic and schematic illustrations with each other.

In the first place, I extracted the realistic blood vessels from figure 2 and used them as a prototype. Then, I added the relevant differences in a reduced manner. Hereby, I hope to make the various subtypes more comparable and easier to recognise.

In a next step, I transferred these realistic pictures on two Cartesian coordinate systems, using the distance between the pubic symphysis and the posterior superior iliac spine as ordinate (y-axis), with the anterior superior iliac spine, one of the most prominent surgical landmarks, as point zero.

This way, I can show the top view by using the abscissa (x-axis) in lateral to medial direction, with the outer lip as point zero and the lateral view (seen from medial) by using the abscissa in caudal to cranial direction, with the caudal edge of the iliac crest as point zero.

Now, every point of the represented structure can be depicted in a clear and measurable way including its relation to different surgical landmarks and its neighbouring structures.

For better readability, I placed the abscissas on top of the pictures and applied a reduced geometrical picture language for the relevant muscles (flesh-coloured), which contrast the darker and more delicate blood vessels in an appealing way.

To make it better understandable, I transferred the coordinate system back into the natural situation (fig. 4)

The realistic illustrations are made with pencil and additional Photoshop colouration, while the schematic illustrations are made in Adobe Illustrator, a vector based drawing programme, which I will describe later.

## 2.2 The mandible

The mandible, or inferior maxillary bone, is the lowest, largest and strongest bone of the face, which forms the lower jaw and holds the lower teeth. It consists of a horseshoe-shaped body, the corpus mandibulae and two quadrilateral shaped portions, the rami (fig. 11).

The body of the mandible consists of two surfaces, an outer and inner surface, and two borders, the superior and the inferior border. The superior, or alveolar border, contains 16 cavities for the reception of the teeth. According to the form of each tooth, the alveolar border varies in width. It is wider at the back than in front and shorter than the inferior border. The latter is rounded and thicker at its anterior side. At the anterior side, the inferior border forms two mental tubercles as corner points of a triangular eminence, the mental protuberance. These tubercles are part of a faint ridge, the mandibular symphysis. During early childhood, the right and left processes fuse together and leave that midline articulation. At its posterior end, the inferior border forms the angle of the mandible and thereby the lower border of the ramus, which consists of two processes, the condyloid process and the coronoid process. The condyloid process consists of two portions, the neck and the condyle. The condyloid process is thicker than the flattened coronoid process, which often varies in shape and size. The mandibular notch, a deep semilunar concavity and gateway for the masseteric vessels and nerve, separates both processes.

Four foramina can be noticed in the mandible, two mental foramina underneath each second premolar tooth and two mandibular foramina on the medial surface of the ramus. These two pairs of foramina are connected by the two mandibular canals, which run obliquely downward and forward in the ramus and horizontally forward in the body, closer to the inner surface in the posterior two thirds of their course and closer to the outer surface in their last one. Underneath the mandibular foramen, the mylohyoid groove runs obliquely downward and forward too, lodging the mylohyoid vessels and nerve.

One of the main functions of the mandible is to allow mastication, this is why four different muscles are connected to it (fig. 12). These are the masseter muscle at the lateral surface of the ramus, the temporalis muscle at the coronoid process, the medial pterygoid muscle at the condyloid process and the lateral pterygoid muscle at the medial surface of the ramus.

Furthermore, the inner surface of the mandible is attached to the four muscles of the base of the mouth, namely the mylohyoid muscle, the genioglossus muscle, the geniohyoid muscle and the anterior belly of the digastric muscle. The outer surface of the mandible is attached to six mimic muscles: the buccinator muscle, the platysma, the depressor anguli oris muscle, the depressor labii inferioris muscle, the mandibular fascicle of the orbicular oris muscle and the mentalis muscle.

The blood supply of the lower jaw is insured by different arteries and veins, which arise from the external carotid artery and the internal jugular vein respectively retromandibular vein. Of main interest for the surgeon are the facial artery and vein, which are very suitable for end-to-end anastomosis with the DCIA/DCIV, thanks to their similar diameters.

Depending on each individual situation, an end-to-side anastomosis of the DCIA/DCIV to the external or internal carotid artery and jugular vein can be the surgeons first choice too, whereas smaller blood vessels like the superior and inferior labial artery and vein, the buccal artery and vein or mental and submental artery and vein, cannot insure the survival of the flap due to their insufficient blood pressure.

The inner surface of the mandible is mainly innervated through the different branches of the mandibular nerve, which is the largest of the three divisions of the trigeminal nerve and proceeds from the inferior angle of the trigeminal ganglion. It originates from two roots and divides into two main branches, the lingual nerve and the inferior alveolar nerve. Latter passes through the mandibular canal to leave it via the mental foramen as the mental nerve.

On the outer surface of the mandible, the extracranial segment, or motor root, of the facial nerve controls the

muscles of facial expression. The facial nerve originates from the brainstem and leaves the cranium via the stylomastoid foramen. It passes the outer ear and continues anteriorly and inferiorly into the parotid gland, where it divides into five branches: the temporal, zygomatic, buccal, marginal mandibular and cervical branch (fig. 12).

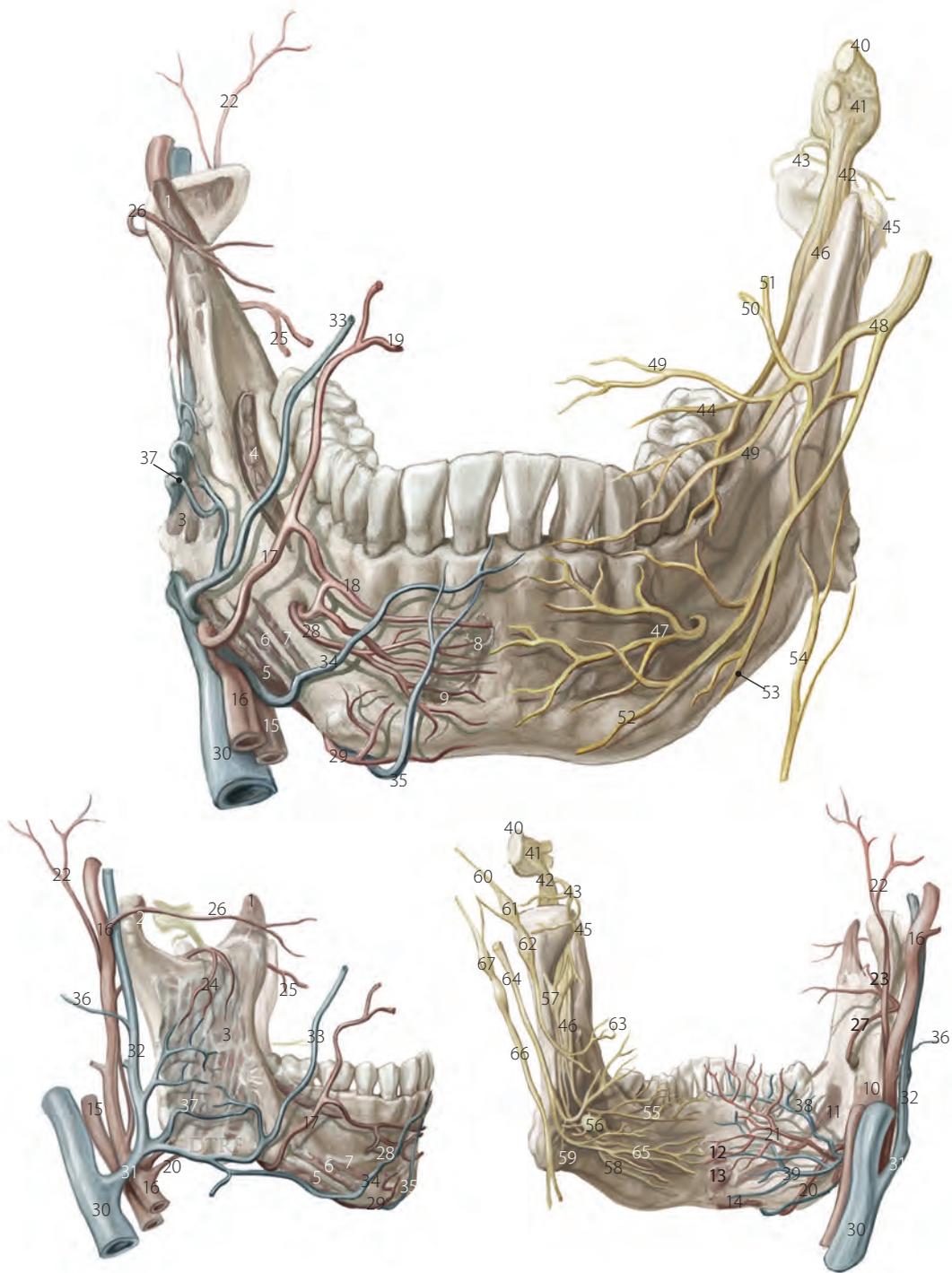
#### **Drawing Technique Figures 11-12**

*In cases of gunshots etc. unpredictable damages can occur. This is the reason why I chose to show an overview of the main important anatomy as it appears in a healthy situation. First, I drew the mandible from three different points of view to capture the complexity of the form. Then, I focused on the structures necessary for revascularisation and indicated muscles and their attachments. In addition to the nerves on the opposite site, I hope to clarify the complex anatomical area of the lower jaw to give a defined picture of exactly the information, which is useful for the surgeon.*

*As these drawings are also concerning anatomy, I applied techniques, described in part 2.1.*



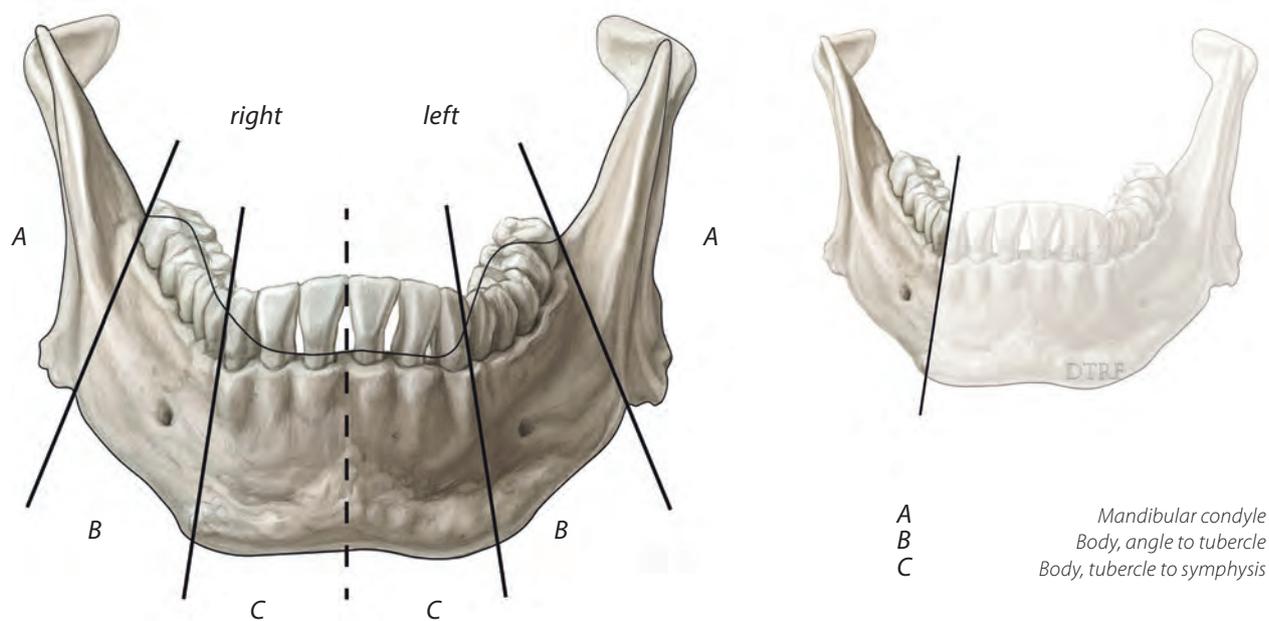
**Figure 11:**  
Mandible, from ventral, lateral and dorsal view



**Figure 12**  
Mandible, from ventral, lateral and dorsal view, including relevant vessels, muscles and nerves

# 3

## The iliac crest in comparison



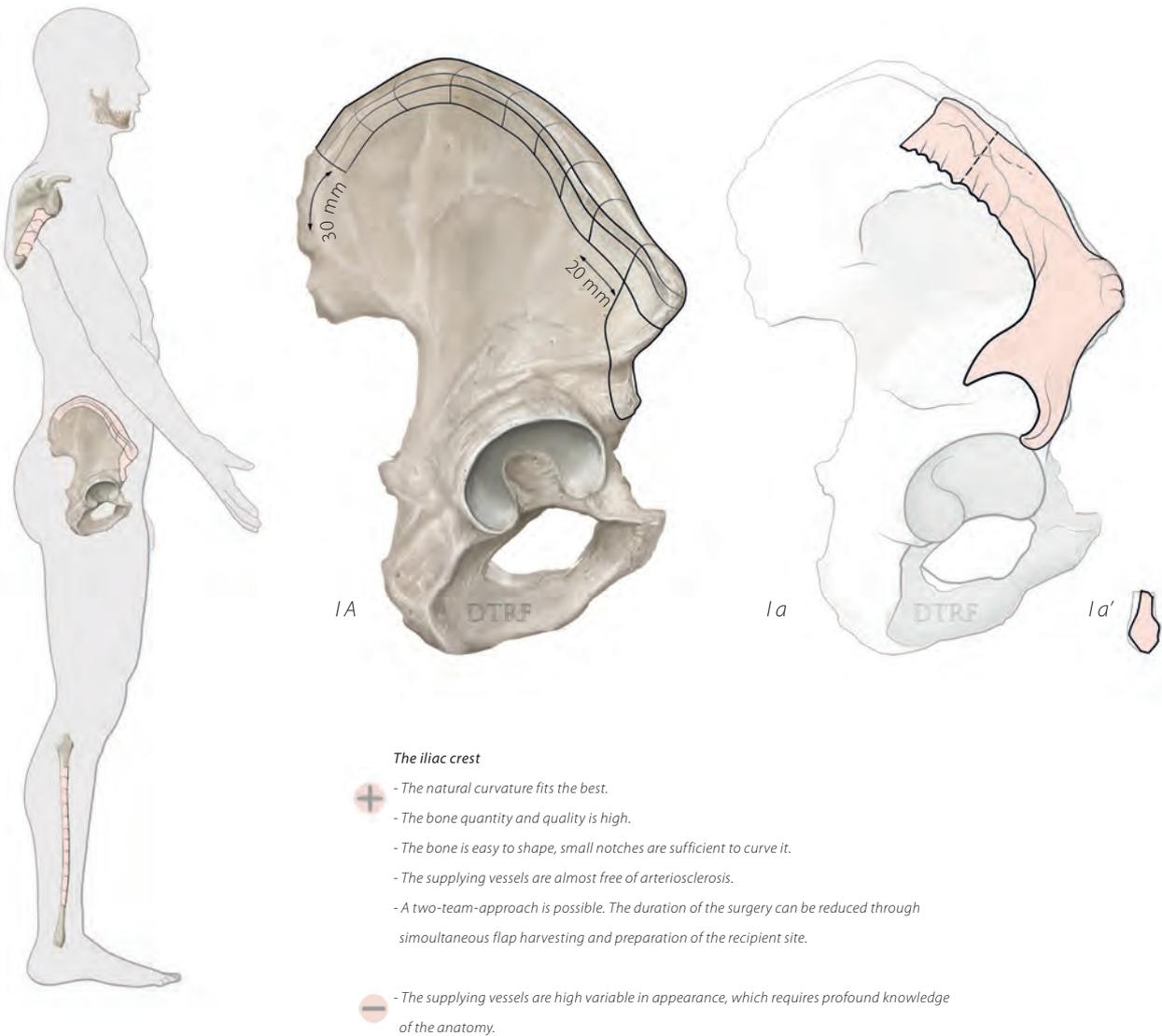
**Figure 13**  
Mandibular segments and maximal resected bone quantity (A left, B left, C left, C right)

The main benefits of the Iliac crest for harvesting bone flaps are the high amount of available bone, the high bone quality and the reliability of its blood vessels concerning the absence of arteriosclerosis. In particular patients with oral cancer, which is favoured by continuous alcohol and tobacco consumption, tend to suffer from arteriosclerosis and poor blood supply in their lower legs. That often makes the anastomoses of fibula flaps in the jaw more risky and unreliable.

In aesthetic aspects, the skin paddle, which is nourished by the final perforator of the DCIA, is less hairy than the

skin paddle provided by the osteocutaneous fibula flap and consequently more suitable for transplantation into the face.

Above that, the iliac crest is softer and easier to shape than the fibula. Smaller notches are sufficient to curve the iliac bone, while the fibula has to be cut completely in most cases. So, the fibula graft consists of more separated pieces and has to be grounded more extended in the recipient site than the iliac bone. With this, the use of screws and thereby foreign tissue can be reduced to a minimum.



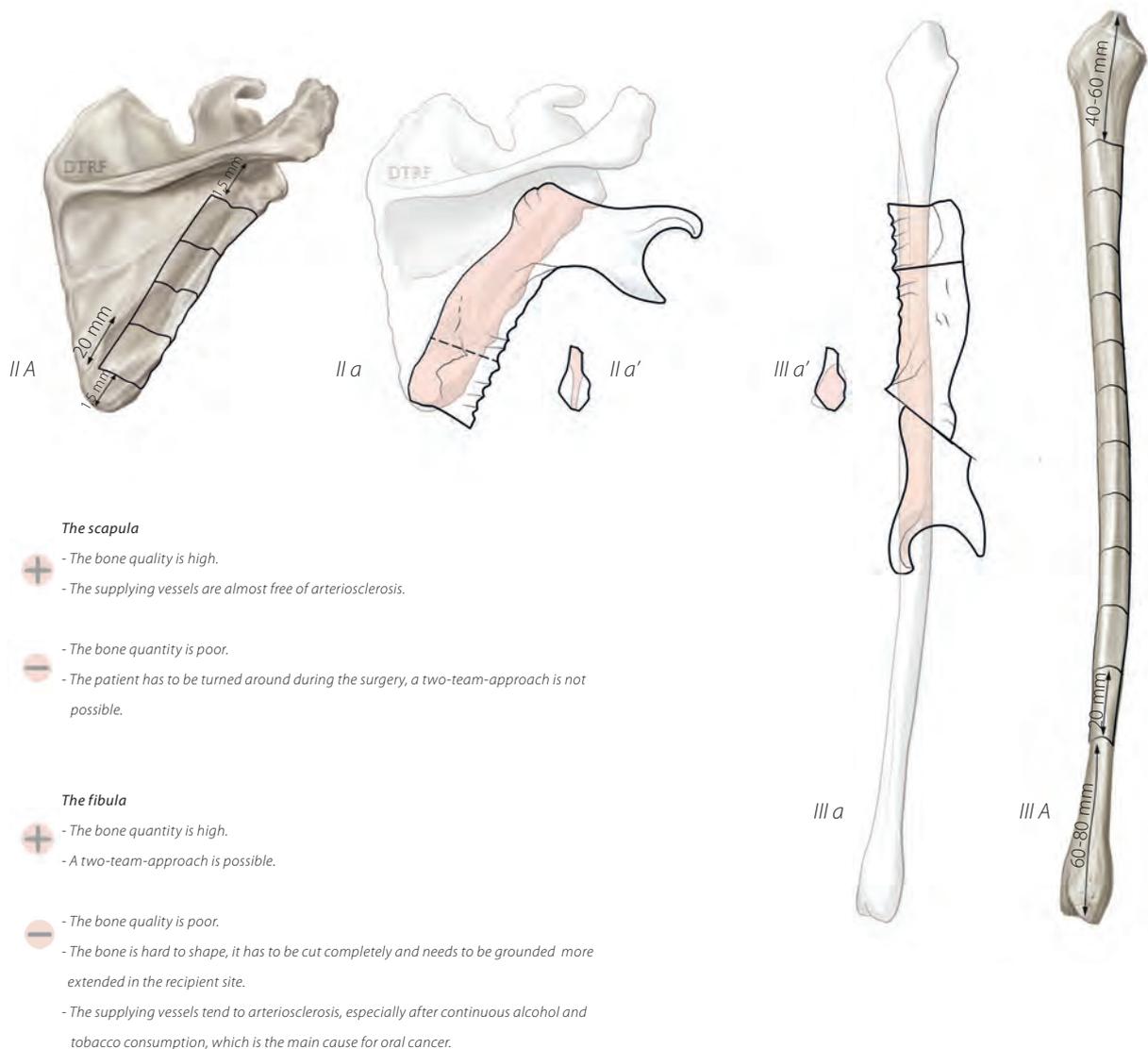
**Figure 14**  
Available (A) and required bone (a) of the iliac crest (I) from lateral view and in cross section (a')

#### Drawing Technique Figures 14-15

To compare the bone quantity of the three most common donor sites for oromandibular reconstruction, that is the iliac crest, the fibula and the scapula, I chose to combine two different techniques in two series. The first series focuses on the maximal available bone quantity of the donor site itself, while the second one concentrates on the maximal required bone quantity by also taking the form of the mandible into account.

For the first series, I used detailed and realistic drawings of the donor sites to underline the fact, that their depicted quantity results from their own accord, their length, height and thickness.

In the second series in contrast, I represented the maximal suitable bone by the tinted intersections of the mandible itself and each donor site. To keep the focus on the overlap of both forms, I used a reduced line art technique with different colours



**Figure 15**  
Available (B, C) and required bone (b, c) of the scapula (II) and the fibula (III) from dorsal view (scapula), lateral view (fibula) and in cross section (b' c')

for donor sites and mandible. In addition to cross-sections, which are relevant for dental implantation, which requires a minimal bone thickness of 5,25 mm, the advantages of the iliac crest according to its bone quantity becomes visible.

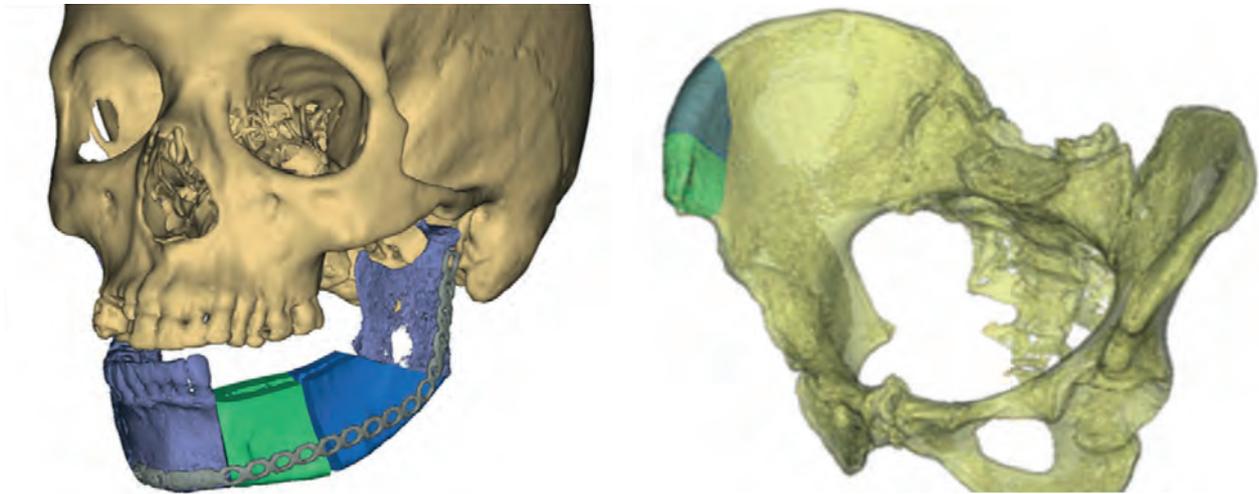
Adobe illustrator is a vector-based programme and therefore very suitable for line art, since the created lines, or paths, are made of connected anchor points, which can be changed and controlled very easily. The drawings can also be enlarged

without loss of information and sharpness, in contradiction to pixel-based programmes like Adobe Photoshop. With the aid of the "width tool" and different line profiles, these uniform lines can be edited and changed in thickness on different places to receive a more organic and personal picture. To create some three-dimensionality under consideration of the standard light source, that comes from the upper left corner, I gradually made the lines thinner in the upper left corner and consecutive darker on the side averted to that light source. Some minor shading intensified that effect.

# 4

## The surgery

## 4.1 The preoperative computer assisted planning



**Figure 16**  
*3D visualisation of the recipient and the donor site, including the reconstruction of the defect*

In many cases of cancer, PD Ghassemi performs a two-step-reconstruction, in which the diseased structures of the jaw are removed six months before the actual reconstruction takes place. Based on the high variety of causes and my general focus on bone reconstruction in this thesis, I confine myself to the second, reconstructive step. That usually is performed as a two-team-approach, with simultaneous bone flap harvesting and preparation of the recipient side.

The second step of that two-step-reconstruction has to be prepared carefully with the help of computer assisted preoperative planning.

Therefore, a high quality 3D visualisation of the defect is calculated and reconstructed virtually with the aid of CT

scans of the donor site and the mandible. The best fitting position of the flap according to its supplying vessels, the best possible curvature, occlusion of the defect and possibility for dental rehabilitation is calculated as well.

To transfer these results to the patient, a harvesting guide, that fits uniquely to the iliac crest, is designed and manufactured by the use of prototyping selective laser sintering, where polyamide powder is solidified by a carbide laser. Above that, an anatomical model of the mandible is fabricated by using a stereolithographic technique. That biomodel can be used to review the shape of the flap before it is inserted into the defect.

## 4.2 The bone flap harvesting

After localisation of the iliac crest and the external iliac artery and vein via palpation, their position is drawn on the patients skin to avoid injury of the blood vessels and to depict the incision line right on the palpable margin of the iliac crest and next to the expected course of the DCIA (fig. 17).

Since the DCIA's origin is quite superficial, the whole situation can be displayed through deepening dissection beginning from that point. Electro cautery is used to stop internal bleeding from small vessels. In consideration of the different subtypes described in part 2.1, every expected branch of the DCIA, DCIV and SCIA has to be located, identified and marked with loops, before the non-essential ascending branch of the isolated DCIA can be sealed and separated from the horizontal branch (fig. 18).

During the whole procedure, the surgeon tries to keep every vulnerably structure, like nerves and peritoneum, in sight, to avoid injuries and donor site complications.

Now, the required iliac bone can be skeletonised from lateral to medial by cutting off all detached muscles and ligaments under strict sparing of its nourishing vessel, until the harvesting guide can be placed on the lateral side of the iliac crest using osteosynthesis screws (fig. 19).

With the aid of a micro oscillating saw, cooled by water, the bone flap can now be harvested exactly as planned (fig. 20) and the stereolithographic biomodel can give a first controlling feedback.

Remaining soft tissue is removed carefully with surgical pincers until the bare bone emerges. The horizontal branch of the DCIA and DCIV is now sealed and cut off its nourishing vessel, according to the required length, but anyway before the DCIV separates into its two accompanying divisions (fig. 21).

On that point, the ischemic time starts, in which the transplant is not supplied with oxygen. By cutting notches into the flap, the soft bone can be shaped perfectly. The gap arising hereby needs to be filled up with osseous tissue resulting from the planned and separated excess length on the posterior end of the bone flap (fig. 21).

Every little bone graft, which was cut off the flap to receive the desired form, is useful to fill up smaller gaps, while the flap is fayed into the defect.

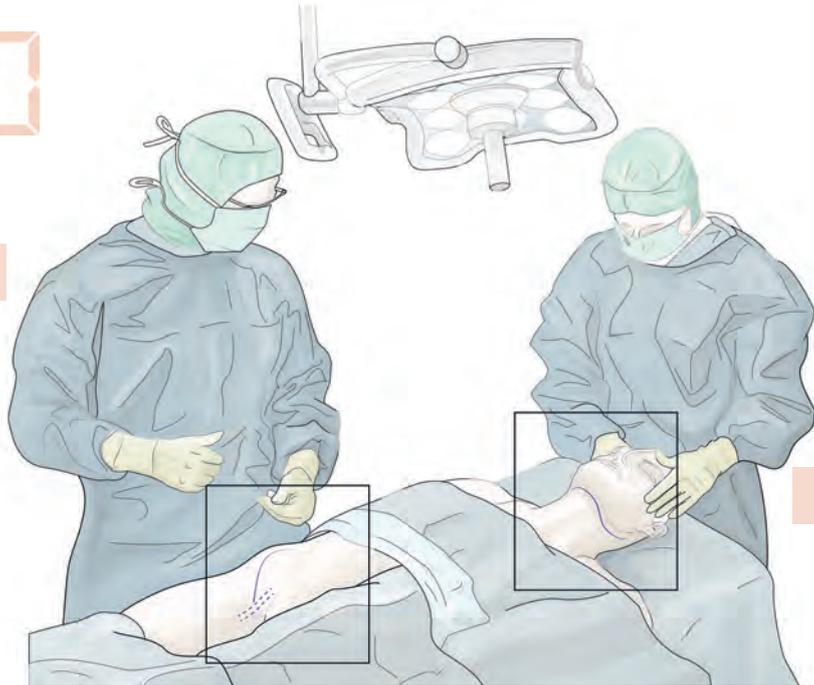
Before that, the recipient site has to be prepared simultaneously to the bone flap harvesting according to the steps described in part 4.3.

However, the cut surface of the remaining iliac bone has to be treated with bone wax to stop bleeding. Additionally, two drains are put into place, to remove blood from the wound area and to avoid swelling and bacterial growth (fig. 22).

Furthermore, the different muscle layers have to be sutured under each other and against each other to stabilize the detached tissue and to take over the counteraction of the missing bone. Finally, the subcutaneous tissue can be sutured and the skin incision can be closed with surgical staples.

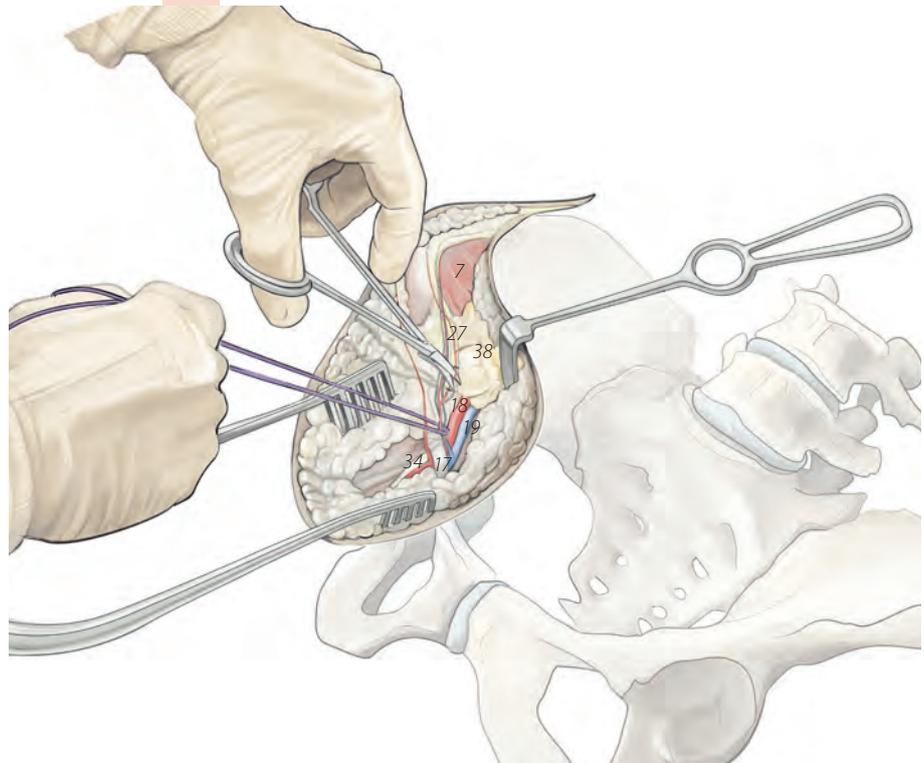
According to long-term studies, the patient can reach his initial ambulatory ability approximately after one year.

00:00



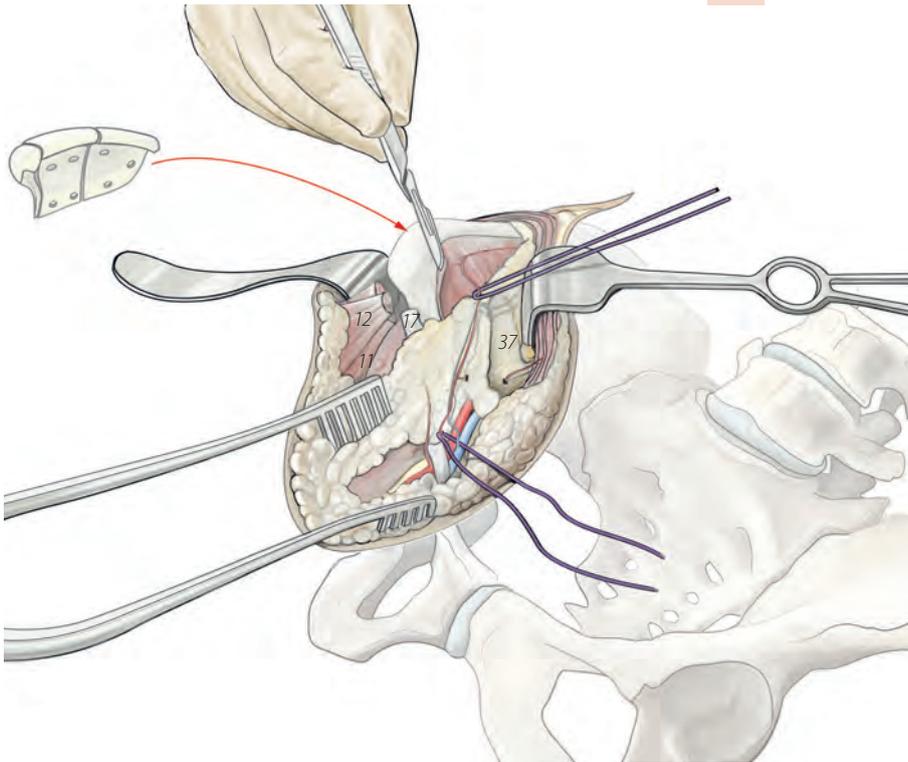
*Figure 17*  
*Two-team-approach*

*Figure 18*  
*Isolation of the HB, sealing of the AB*

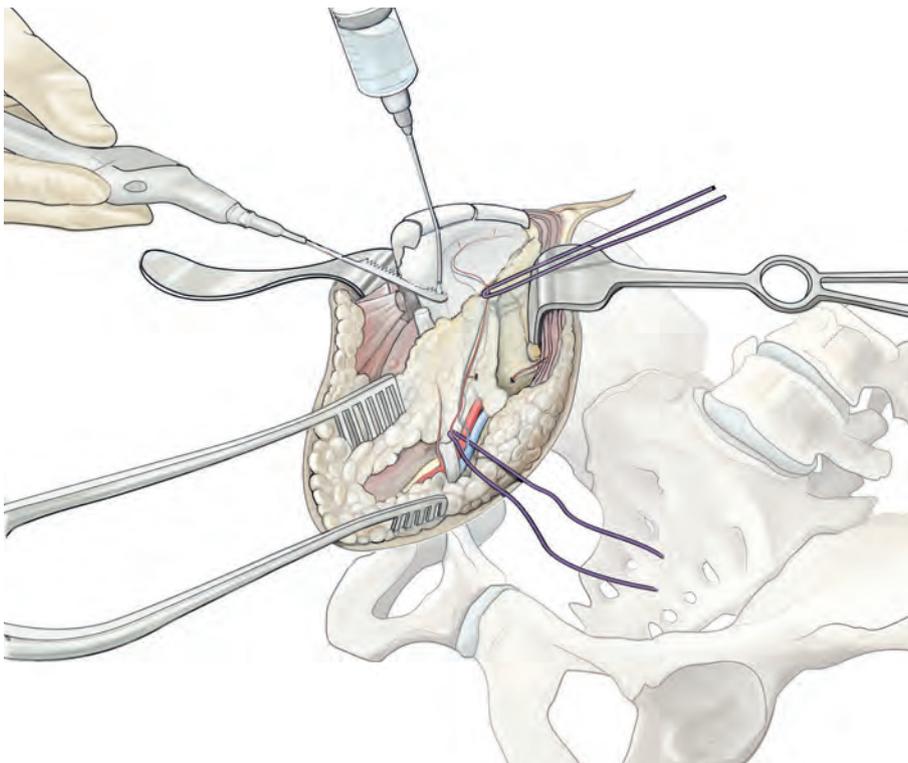


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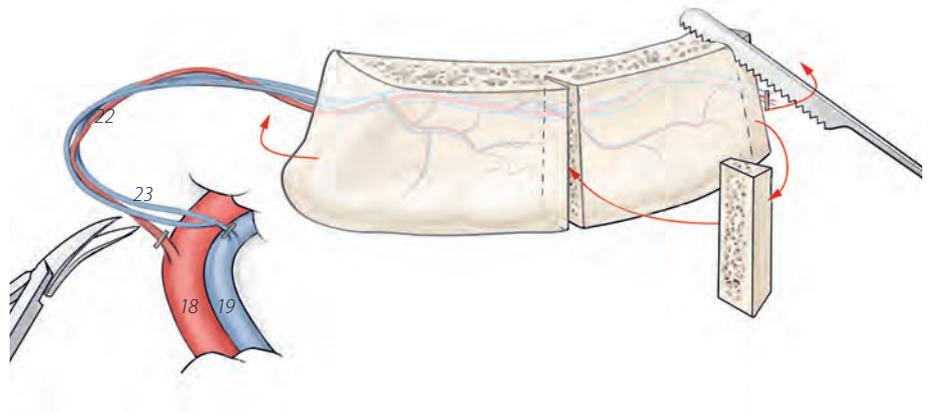
**Figure 19**  
*Skeletonising of the iliac crest*



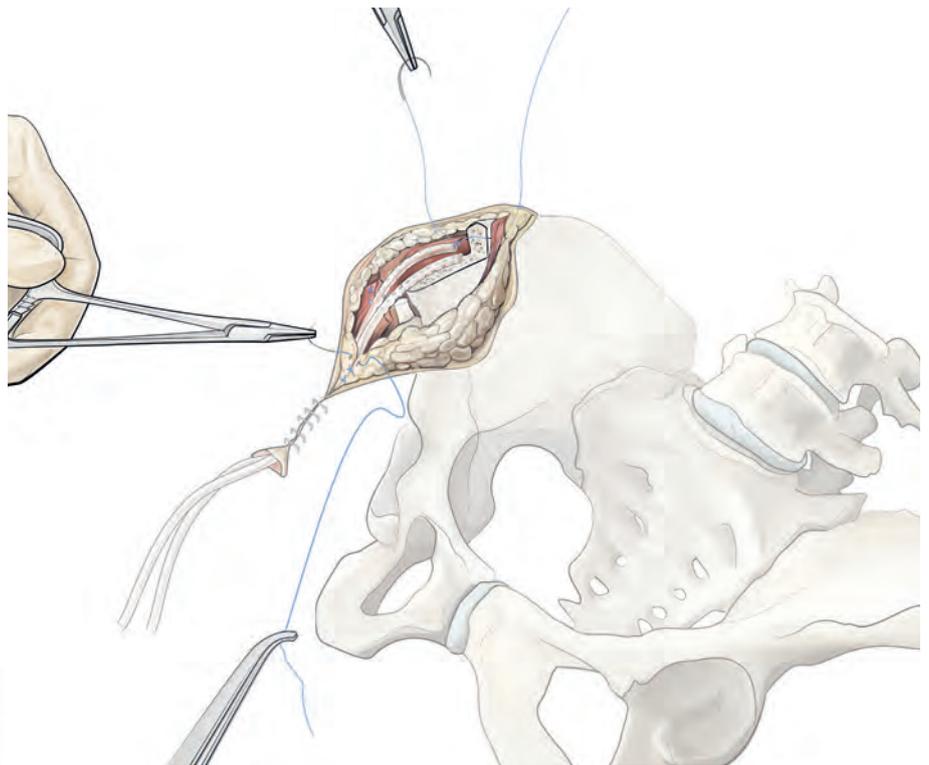
**Figure 20**  
*Harvesting of the flap*

01:30

02:00



*Figure 21*  
*Modelling of the flap*



*Figure 22*  
*Closure of the incision*

02:00

## 4.3. The preparation of the mandible

Before the skeletonised iliac bone flap can be fayed into the defect, the recipient site has to be prepared.

Firstly, an incision is made four centimeters inferior to the edge of the mandible to spare the facial nerve (fig. 17).

The mandible is dissected carefully until the old titanium plate, which stabilised the remaining parts of the mandible, can be removed with the aid of screwdrivers (fig. 23).

Tissue samples from the bone and neighbouring structures, as formerly occupied nerves et cetera, can be taken during that phase, to insure the recovery of the patient (fig. 24).

The suitable blood vessels must be dissected, determined and marked with loops and the new reconstruction plate has to be inserted using osteosynthesis screws (fig. 25). The new plate is manufactured during the preoperative computer assisted planning and can be delivered as unchangeable sintered titanium plate or as changeable milled version, which provides more inter surgical flexibility.

In many cases PD Ghassemi prefers a mini plate, which is better tolerated than the bigger plates illustrated in figures 24-27.

Now, the skeletonised bone flap can be fayed into the defect and potential gaps can be filled up by the use of bone grafts, cut off during flap modulation (fig. 26).

The flap is turned up side down to replace the inferior border of the mandible by the upper most margin of the iliac crest.

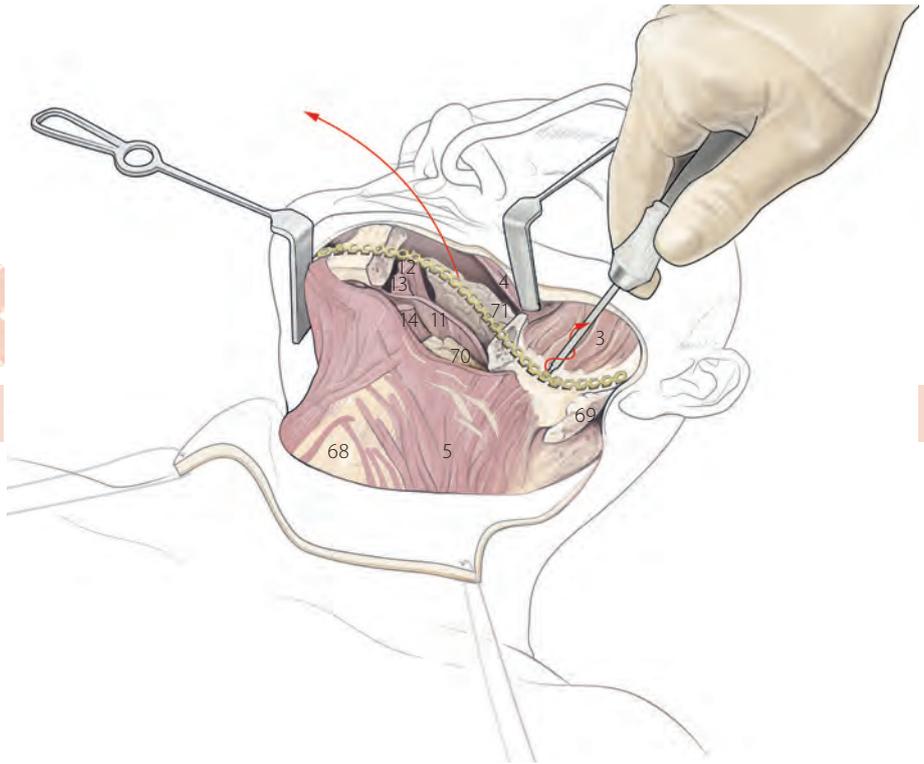
Finally the blood vessels can be connected micro-surgically in order to revascularise the flap (fig. 26).

In end-to-end anastomoses of two vessels of approximately the same size, the most marginal points of both vessels are stitched up first to provide penetration of the opposite side, while the first side is sutured. In end-to-side anastomoses, the bigger blood vessel is pinched off and cut open at one side and connected to the end of the smaller vessel. Clamps, staples and tandem temporary clip approximators are used to interrupt blood flow temporarily until the anastomoses are completed.

When the blood supply is working adequately, the incision in the neck can be closed (fig. 27).

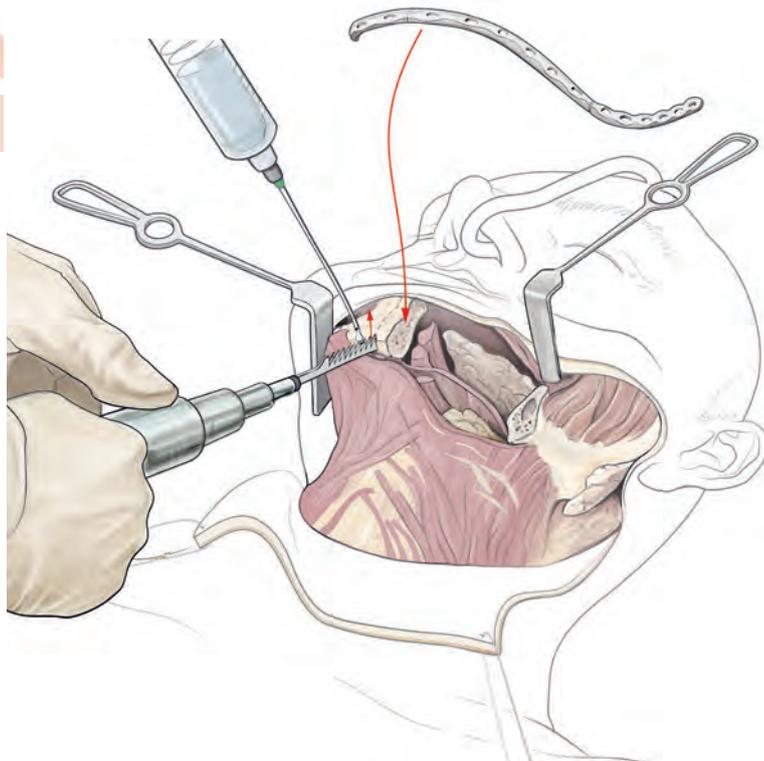
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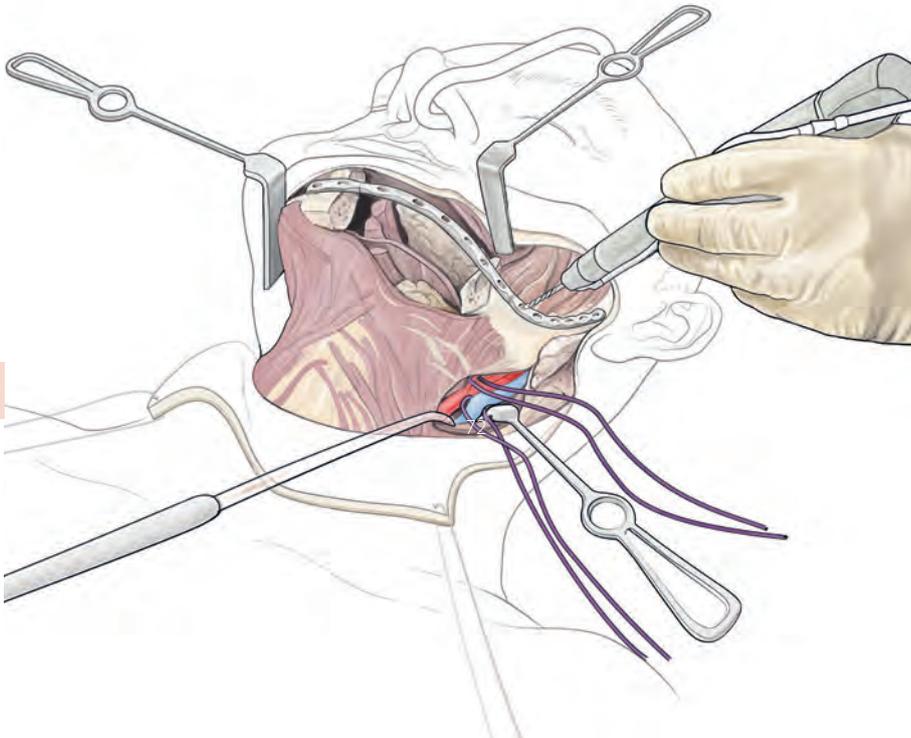
**Figure 23**  
Removal of the old plate



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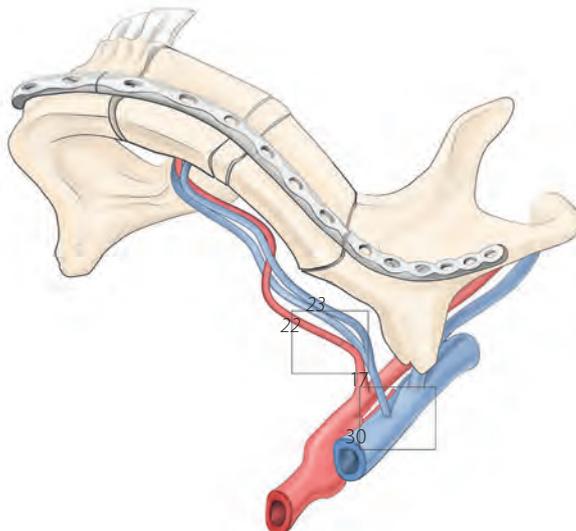
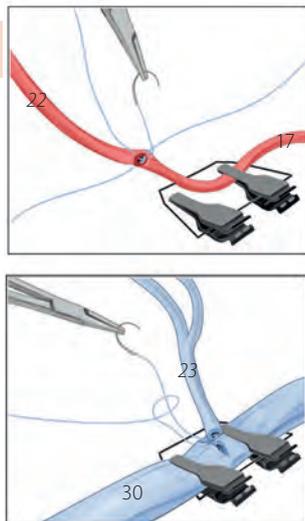
**Figure 24**  
Removal of specimens to insure  
the recovery of the patient





01:30

**Figure 25**  
 Fixation of the new plate  
 and isolation of suitable  
 vessels to revascularise the flap

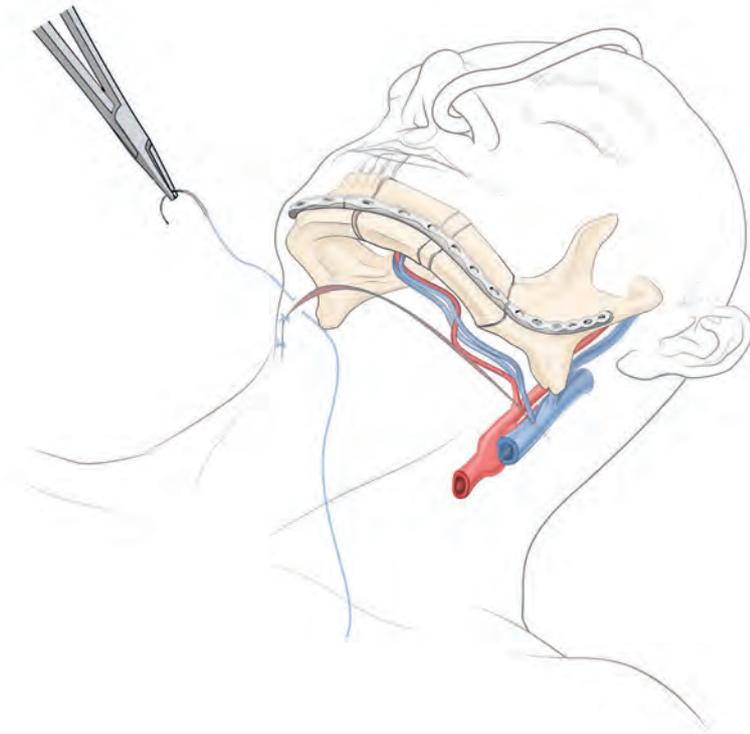


02:15

**Figure 26**  
 Fixation of the flap and  
 anastomosis of the vessels

03:00

**Figure 27**  
Closure of the incision



### **Drawing Technique Figures 17-27**

To reflect the tidiness of an operating room in combination with the efficient charisma of a manual, I combined line art with a clean Adobe Photoshop colouration to illustrate the major steps of the procedure. Compared to my illustrations concerning the anatomy, I reduced the level of detail to a minimum. To keep the focus on the instrumental use and less on the anatomical structures involved, I only gave some more details to the hands and the instruments, using the same pencil technique described in part 2.

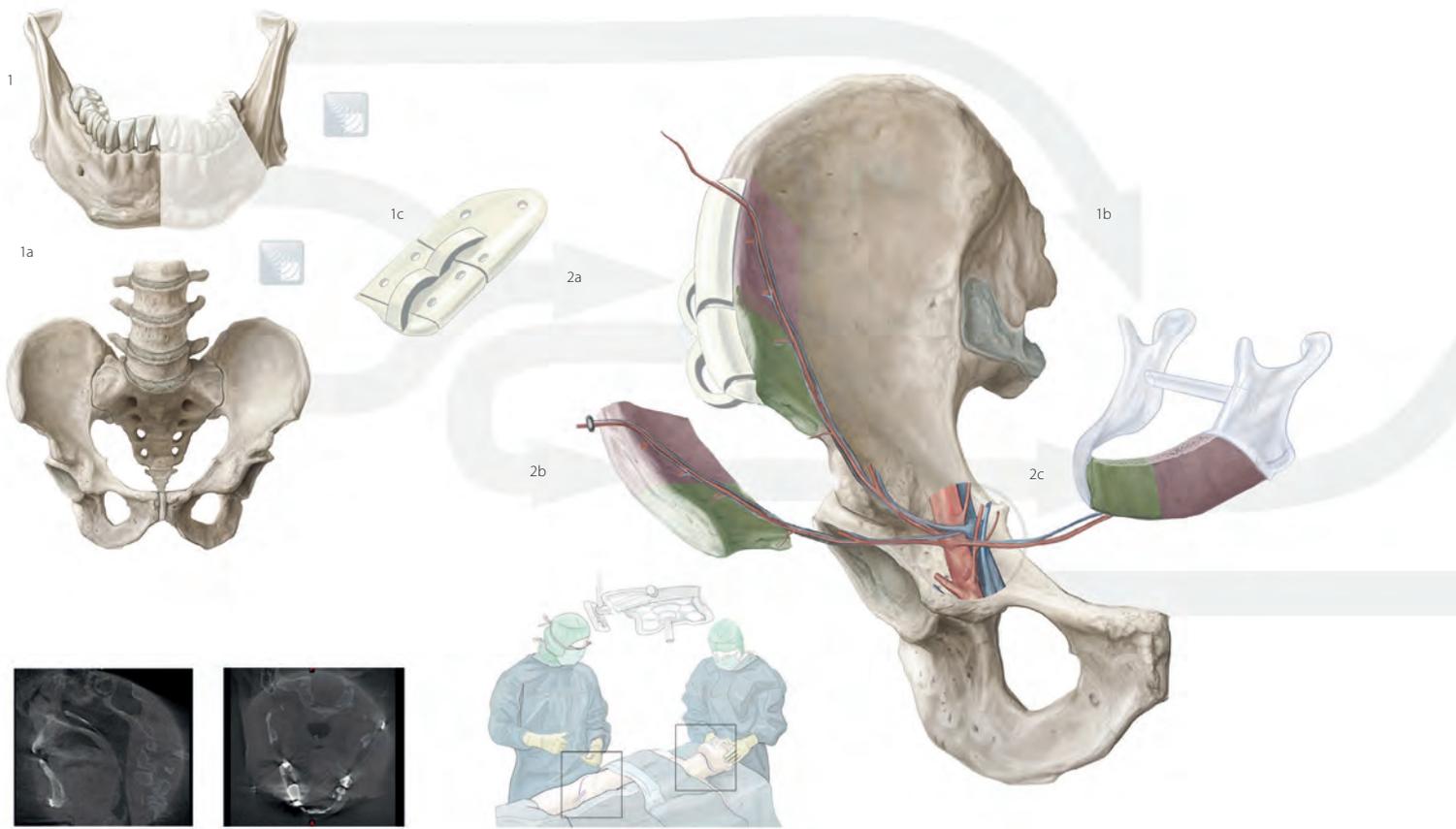
Since the approach is performed with two teams simultaneously, I first made an illustration of the whole situation to serve as starting point for two series, that depict the actions of both teams.

Due to the fact, that PD Ghassemi performed the surgery for the first time at the Bremerhaven Hospital Reinkenheide, both lines of action were performed by himself. So I had the chance to follow the complete procedure without missing any information. Nevertheless, I depicted the situation as it is meant to happen, showing both, the iliac bone flap harvesting and the mandibular preparation, including the insertion of the flap, in each 5 illustrations.

In the first series, I extracted the essential information from figure 17, which is only the position of the pelvis. So I chose to show the operation area on the pelvis without any repetition of surrounding elements like surgical drapes, body contour et cetera.

In the second series, I chose to maintain the patient's head in some illustrations to show the operation area in interaction to the surrounding structures and to emphasise the final situation as a reconstructive goal.

## THE VASCULARISED, SKELETONISED ILIAC BONE FLAP FOR OROMANDIBULAR RECONSTRUCTION



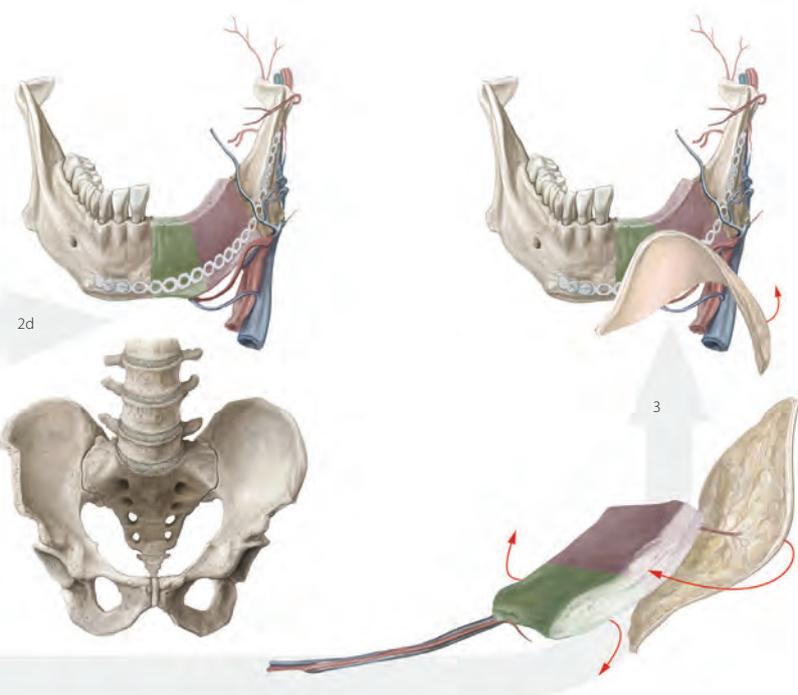
- |   |   |
|---|---|
| <p>1 The preoperative computer assisted planning</p> <p>1a High quality 3D visualisation of the defect (mandible) and the donor site (iliac crest) via CT scan to select the best fitting area of the iliac crest with the position of the DCIA also taken in account</p> <p>1b Stereolythic biomodel of the defect created on basis of the CT scan to shape the flap during the operation</p> <p>1c Surgical guide created on basis of the intersection of the defect and the best fitting area of the iliac crest</p> | <p>2 The operation</p> <p>2a The surgical guide fixed temporarily on the external side of the skeletonised iliac crest using osteosynthesis screws</p> <p>2b The iliac bone flap exactly sawed with the help of the surgical guide, still nourished by the external iliac artery</p> <p>2c The iliac bone flap shaped with the help of the stereolythic biomodel, still nourished by the external iliac artery</p> <p>2d The perfect fitting flap fixed with the help of the reconstruction plate and osteosynthesis screws</p> <p>2e The deep circumflex iliac artery and vein anastomosed to the facial artery and vein, the external and/or carotid artery and vein and/or external jugular vein</p> |
|---|---|

Figure 28 Patient Information

### Drawing Technique Figure 28

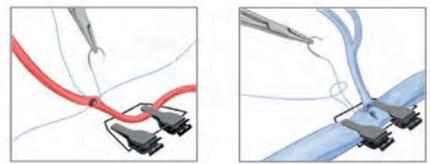
Illustrations for patient information have to answer different questions than illustrations for surgeons. While inter surgical actions are more interesting to the surgeon, more trivial information such as set up in the operation room can be interesting to the patient. Especially instruments and their use

inside the body may have a confronting affect to the patient without giving any useful information. From the surgeons point of view in contrast, the instruments and the position of the hands using them, may be essential to understand surgical manuals. That applies to anatomical structures not



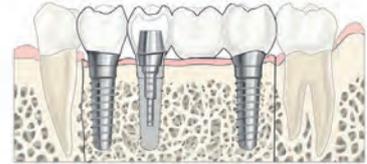
2d

2e

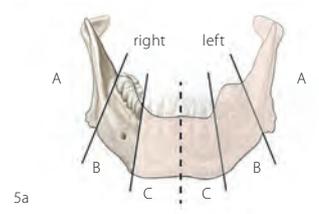


3 The osteocutaneous flap  
The skin nourished by the deep circumflex iliac artery taken as skin paddle to reconstruct lost skin

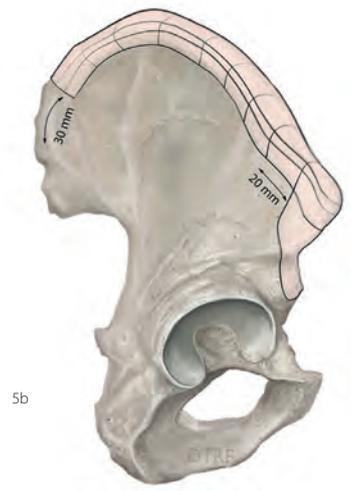
4



4 Dental restoration  
Dental implants can be implanted directly during the transplantaion of the bone flap, if planned during the preoperative planning, or 4-6 month after the implantation, when the bone flap is healed into the recipient site.



5a



5b

5a Mandibular segments and maximal resected bone quantity

- A Mandibular condyle
- B Body, angle to tubercle
- C Body, tubercle to symphysis

5b Maximal available bone quantity of the donor site

directly involved in the story line, too. Endangered structures, which have to be spared, are not that calmative to thematise widespread in front of a patient. Towards the patient, it is more useful to concentrate on the basic information in a positive way and to depict the planned procedure as it is supposed to happen.

For this reason, I chose to make a patient information, which shows the major steps in an abstracted way, using Illustrations of every part of my thesis to fulfil the patients' needs in an appealing way.

## Conclusion

A variety of techniques is used for different purposes. Not only to emphasise the diverse aspect of each topic, but also to represent the range of skills I obtained during my studies in Maastricht. In conclusion, this Thesis represents my state of knowledge and skills at this time and aims to display my professional development between the two professions, Scientific Illustration and Scenography, which I learned and practiced alternately.

In particular the cooperation with PD Ghassemi and my first contact to the different working areas of a scientific illustrator strengthened my self-confidence. I hope to have the opportunity to practice this profession for a long time and to transfer my analogue knowledge, techniques and ways of thinking in the digital era, more and more. I hope to keep up and to extend my standards and abilities under the pressure of a professional career. Different tools may help me on that way, diverse drawing techniques, my pencil, my computer, my photo camera, my basic knowledge about the use of colour, line art, perspective and above all my hands and my brains.

The major goal of my work as scientific illustrator is to extract useful from useless information under different points of view and to repack the resulting essence in one aesthetically appealing picture, which reflects and cherishes the effort science made to achieve that knowledge.

No computer, no camera and no pencil could reach that goal without someone in control, someone who combines all aspects of a specific topic and who searches for creative solutions for complex problems.

# Zusammenfassung

Diese Masterarbeit über das revaskularisierte, skelettierte Beckenkammtransplantat zur oromandibularen Gesichtsrekonstruktion entstand in Zusammenarbeit mit PD Dr. Dr. Alireza Ghassemi, dem Universitätsklinikum RWTH Aachen sowie dem Klinikum Bremerhaven-Reinkenheide. Sie möchte die unterschiedlichen Aspekte des Themas verbildlichen und meine Arbeitsweisen als wissenschaftlicher Illustrator beleuchten. Hierzu gliedert sie sich in drei Teilbereiche: die Anatomie des Beckenkammes und des Unterkiefers, dem Vergleich des Beckenkammes mit anderen Knochentransplantaten sowie dem von Prof. Ghassemi durchgeführten, operativen Eingriff. Die gesamte Arbeit basiert inhaltlich auf den bisherigen sowie zukünftigen Studien von PD Ghassemi.

Der Beckenkamm gilt aufgrund seiner Form, seiner hohen Knochenmasse, Knochenqualität und -flexibilität sowie der Qualität seiner Blutgefäße als eine der günstigsten Regionen zum Heben revaskularisierter Knochentransplantate zur oromandibularen Gesichtsrekonstruktion. Insbesondere seine in Bezug auf Anzahl und Verlauf der einzelnen Äste außergewöhnlich variable Blutversorgung bedarf hierbei besonderer Aufmerksamkeit, da diese zur weiteren Versorgung des Transplantates mit entsprechenden Blutgefäßen der Kieferregion anastomosiert werden muss. Eine genaue Differenzierung der einzelnen Äste der A. circumflexa ilium profunda unter Einbezug ihrer Variationsmöglichkeiten ist daher unabdingbar. Diese Variationen wurden am Uniklinikum RWTH Aachen anhand von 78 beidseitigen Präparationen sowie 60 klinischen Fällen dokumentiert und in dieser Thesis illustriert.

Aufgrund der oft verwirrenden Anatomie des Beckenkammes und den damit assoziierten Komplikationen, wird oftmals dem Fibula- bzw.

Scapulatransplantat zur Kieferrekonstruktion der Vortritt gewährt. Ein Vergleich dieser drei Transplantate soll somit die Vorteile des Beckenkammes darstellen und untermauern.

Der im letzten Teil meiner Arbeit beschriebene operative Eingriff beinhaltet die Skelettierung des Beckenkammes und die Transplantation eines reinen Knochentransplantates ohne Muskulatur. Durch die damit einhergehende Reduktion der Transplantatgröße können die Nachteile des Beckenkammes vermieden werden und seine Vorteile im Wohle des Patienten zur Geltung kommen.

Dieser Eingriff erfolgt je nach Ausgangssituation als zweiter Teil einer Two-step-reconstruction. In einer vorangehenden, ersten Operation, wird krankhaft verändertes Knochengewebe entfernt und in einem zweiten Eingriff ersetzt. Hierbei wird parallel zur Hebung des Beckenkammes der Unterkiefer auf das Transplantat vorbereitet, wodurch die Dauer der Operation auf ein Minimum reduziert werden kann.

In einem weiteren Schritt wird durch Zahnimplantate die Funktionsfähigkeit des Kiefers weiter rekonstruiert.

In dieser Thesis konnte ich den Vor- und Nachteilen des Beckenkammes praxisbezogene Lösungsansätze gegenüberstellen und neue Erkenntnisse mittels wissenschaftlicher Illustration vermitteln. Durch die Zusammenarbeit mit PD Dr. Dr. Ghassemi habe ich die verschiedenen Arbeitsbereiche eines medizinischen Illustrators kennengelernt, meine Kompetenzen weiter entwickelt und meine im Studium zum wissenschaftlichen Illustrator erworbenen Fähigkeiten anwenden können. Somit spiegelt diese Thesis den momentanen Stand meiner Fähigkeiten wider, welche ich im Zuge meiner zukünftigen Laufbahn weiter entwickeln möchte.

# Acknowledgement

I first want to thank my teachers, Jacques Spee, Ilse Wielage, Arno Lataster, Greet Mommen and Rogier Trompert, my mentor in this Thesis, as well as my fellow students. Thanks for your advice, your patience and the wonderful learning atmosphere all of you have created.

Special thanks to PD Dr Dr Ghassemi who guided me through the project and who shared his knowledge.

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Furthermore, my thank goes to my family, my friends and Gloria Kempelmann, who corrected my English text.

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# Colophon

Cover	Illustrations of the pelvis and the mandible.
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Dirk Traufelder, Medical Illustrator  
d.traufelder@live.de / www.dirk-traufelder.de

LEGEND DONOR SITE Figures 1, 2, 4-6, 18-22

- 1 Anterior superior iliac spine (ASIS)  
- *Spina iliaca anterior superior*
- 2 Anterior inferior iliac spine (AIIS)  
- *Spina iliaca anterior inferior*
- 3 Posterior superior iliac spine (PSIS)  
- *Spina iliaca posterior superior*
- 4 Pubic symphysis - *Symphysis pubica*
- 5 Quadratus lumborum muscle  
- *M. quadratus lumborum*
- 6 Psoas major muscle - *M. psoas major*
- 7 Iliacus muscle - *M. iliacus*
- 8 Abdominal external oblique muscle  
- *M. obliquus externus abdominis*
- 9 Abdominal internal oblique muscle  
- *M. obliquus internus abdominis*
- 10 Transverse abdominal muscle - *M. transversus abdominis*
- 11 Tensor fasciae latae muscle - *M. tensor fasciae latae*
- 12 Sartorius muscle - *M. sartorius*
- 13 Piriformis muscle - *M. piriformis*
- 14 Gluteus medius muscle - *M. gluteus medius*
- 15 Gluteus minimus muscle - *M. gluteus minimus*
- 16 Iliolumbar ligament - *Lig. iliolumbale*
- 17 Inguinal ligament - *Lig. inguinale*
- 18 External iliac artery (EIA) - *A. iliaca externa*
- 19 External iliac vein - *V. iliaca externa*
- 20 Femoral artery - *A. femoralis*
- 21 Femoral vein - *V. femoralis*
- 22 Deep circumflex iliac artery (DCIA)  
- *A. circumflexa ilium profunda*
- 23 Deep circumflex iliac vein (DCIV)  
- *V. circumflexa ilium profunda*
- 24 Superficial circumflex iliac artery (SCIA)  
- *A. circumflexa ilium superficialis*
- 25 Superficial circumflex iliac vein (SCIV)  
- *V. circumflexa ilium superficialis*
- 26 Horizontal branch of the DCIA (HB)
- 27 Ascending branch of the DCIA (AB)
- 28 Inferior epigastric artery - *A. epigastrica inferior*
- 29 Superficial epigastric artery - *A. epigastrica superficialis*
- 30 Superficial epigastric vein - *V. epigastrica superficialis*
- 31 Iliolumbar artery - *A. iliolumbalis*
- 32 Lumbar branch of the iliolumbar artery  
- *R. lumbalis arteriae iliolumbalis*
- 33 Iliac branches of the iliolumbar artery  
- *Rr. iliaca arteriae iliolumbalis*
- 34 Lumbar artery IV - *A. lumbalis IV*
- 35 Internal iliac artery - *A. iliaca interna*
- 36 Iliohypogastric nerve - *N. iliohypogastricus*
- 37 Ilioinguinal nerve - *N. ilioinguinalis*
- 38 Lateral femoral cutaneous nerve  
- *N. cutaneus femoris lateralis*
- 39 Femoral nerve - *N. femoralis*
- 40 Genitofemoral nerve - *N. genitofemoralis*
- 41 Obturator nerve - *N. obturatorius*
- 42 Peritoneum - *Peritoneum*
- 43 Preperitoneal fat
- 44 Psoas minor muscle - *M. psoas minor*

LEGEND RECIPIENT SITE Figure 11

- 1 Head of the mandible - *Caput mandibulae*
- 2 Pterygoid fovea - *Fovea pterygoidea*
- 3 Condylod process - *Proc. condylaris*
- 4 Coronoid process - *Proc. coronoides*
- 5 Oblique line of the mandible - *Linea obliqua*
- 6 Angle of the mandible - *Angulus mandibulae*
- 7 Mental foramen - *Foramen mentale*
- 8 Body of the mandible - *Corpus mandibulae*
- 9 Ramus of the mandible - *Ramus mandibulae*
- 10 Tubercles of the mandible - *Tubercula mandibulae*
- 11 Alveolar jugae - *Jugae alveolariae*
- 12 Mandibular foramen - *Foramen mandibulae*
- 13 Mylohyoid groove - *Sulcus mylohyoideus*
- 14 Mylohyoid line - *Linea mylohyoidea*

LEGEND RICIPIENT SITE      Figures 12, 23-27

- 1      Temporalis muscle - *M. temporalis*
- 2      Lateral pterygoid muscle - *M. pterygoideus lateralis*
- 3      Masseter muscle - *M. masseter*
- 4      Buccinator muscle - *M. buccinator*
- 5      Platysma - *Platysma*
- 6      Depressor anguli oris muscle - *M. depressor anguli oris*
- 7      Depressor labii inferioris muscle - *M. depressor labii inferioris*
- 8      Mentalis muscle - *M. mentalis*
- 9      Orbicularis oris muscle, mandibular fascicle  
- *M. orbicularis oris, Insertio mandibularis*
- 10     Medial pterygoid muscle - *M. pterygoideus medialis*
- 11     Mylohyoid muscle - *M. mylohyoideus*
- 12     Genioglossus muscle - *M. genioglossus*
- 13     Geniohyoid muscle - *M. geniohyoideus*
- 14     Digastric muscle, anterior belly - *M. digastricus, venter anterior*
- 15     Internal carotid artery - *A. carotis interna*
- 16     External carotid artery - *A. carotis externa*
- 17     Facial artery - *A. facialis*
- 18     Inferior labial artery - *A. labialis inferior*
- 19     Superior labial artery - *A. labialis superior*
- 20     Lingual artery - *A. lingualis*
- 21     Deep lingual artery - *A. profunda linguae*
- 22     Ascending pharyngeal artery - *A. pharyngea ascendens*
- 23     Maxillary artery - *A. maxillaris*
- 24     Masseteric artery - *A. masseterica*
- 25     Buccal artery - *A. buccalis*
- 26     Transverse facial artery - *A. transversa fascie*
- 27     Inferior alveolar artery - *A. alveolaris inferior*
- 28     Mental artery - *A. mentalis*
- 29     Submental artery - *A. submentalis*
- 30     Internal jugular vein - *V. jugularis interna*
- 31     Common facial vein - *V. facialis communis*
- 32     Retromandibular vein - *V. retromandibularis*
- 33     Facial vein - *V. facialis*
- 34     Inferior labial vein - *V. labialis inferior*
- 35     Submental vein - *V. submentalis*
- 36     Posterior auricular vein - *V. auricularis posterior*
- 37     Masseteric vein - *V. masseterica*
- 38     Deep lingual vein - *V. profunda linguae*
- 39     Sublingual vein - *V. sublingualis*
- 40     Trigeminal nerve - *N. trigeminus*
- 41     Trigeminal ganglion - *Ganglion trigeminale*
- 42     Mandibular nerve - *N. mandibularis*
- 43     Auriculotemporal nerve - *N. auriculotemporalis*
- 44     Buccal nerve - *N. buccalis*
- 45     Masseteric nerve - *N. massetericus*
- 46     Inferior alveolar nerve - *N. alveolaris inferior*
- 47     Mental nerve - *N. mentalis*
- 48     Facial nerve - *N. facialis*
- 49     Buccal branches of the facial nerve - *Rr. buccales, N. facialis*
- 50     Zygomatic branch of the facial nerve  
- *R. zygomaticus, N. facialis*
- 51     Temporal branch of the facial nerve - *R. temporalis, N. facialis*
- 52     Marginal mandibular branch of the facial nerve  
- *R. marginalis mandibulae, N. facialis*
- 53     Cervical branch of the facial nerve - *R. colli, N. facialis*
- 54     Great auricular nerve - *N. auricularis magnus*
- 55     Lingual nerve - *N. lingualis*
- 56     Submandibular ganglion - *Ganglion submandibulare*
- 57     Otic ganglion - *Ganglion oticum*
- 58     Mylohyoid nerve - *N. mylohyoideus*
- 59     Medial pterygoid nerve - *N. pterygoideus medialis*
- 60     Glossopharyngeal nerve - *N. glossopharyngeus*
- 61     Superior cervical ganglion - *Ganglion cervicale superius*
- 62     Inferior cervical ganglion - *Ganglion cervicale inferius*
- 63     Tonsillar branches of the glossopharyngeal nerve  
- *Rr. tonsillares, N. glossopharyngeus*
- 64     Hypoglossal nerve - *N. hypoglossus*
- 65     Sublingual nerve - *N. sublingualis*
- 66     Vagus nerve - *N. vagus*
- 67     Caudal ganglion of the vagus nerve - *Ganglion caudale, N. vagus*
- 68     Cervical fascia - *Fascia cervicalis*
- 69     Parotid gland - *Glandula parotidea*
- 70     Submandibular gland - *Glandula submandibularis*
- 71     Sublingual gland - *Glandula sublingualis*
- 72     Sternocleidomastoid muscle - *M. sternocleidomastoideus*