Resection and Reconstruction of Head & Neck Cancers
Head and Neck Cancer Clinics
Head and Neck Cancer (HNC) is a major challenge to public health. Its management involves a multidisciplinary team approach, which varies depending on the subtle differences in the location of the tumour, stage and biology of disease and availability of resources. In the wake of rapidly evolving diagnostic technologies and management techniques, and advances in basic sciences related to HNC, it is important for both clinicians and basic scientists to be up-to-date in their knowledge of new diagnostic and management protocols. This series aims to cover the entire range of HNC-related issues through independent volumes on specific topics. Each volume focuses on a single topic relevant to the current practice of HNC, and contains comprehensive chapters written by experts in the field. The reviews in each volume provide vast information on key clinical advances and novel approaches to enable a better understanding of relevant aspects of HNC. Individual volumes present different perspectives and have the potential to serve as stand-alone reference guides. We believe these volumes will prove useful to the practice of head and neck surgery and oncology, and medical students, residents, clinicians and general practitioners seeking to develop their knowledge of HNC will benefit from them.

More information about this series at http://www.springer.com/series/13779
Resection and Reconstruction of Head & Neck Cancers
The incidences of head and neck cancer had been increasing significantly in the past few decades. Studies indicate that there is a definitive link between the use of tobacco products and betel nuts and the development of oral cancer. The head and neck cancer can cause significant impacts on a person’s daily life such as swallowing, speeches, respiration, and cosmesis and further affect his work and even social status.

The goal of this book is to provide a comprehensive understanding of the head and neck reconstruction, starting from the epidemiology and etiology of head and neck cancer, followed by the principles of head and neck surgery, and ended with the guidelines for head and neck reconstruction. The process of patient selection, preoperative planning, surgical technique, and postoperative care in each geographic area of head and neck are also documented with details in the book.

At Chang Gung Memorial Hospital, we perform an average of 600 head and neck reconstructions per year, with a total of more than 12000 cases with satisfying prospective registry as of today. We are glad to contribute our head and neck reconstruction experiences to the worldwide medical researchers and physicians. All the authors who work in a multidisciplinary team are either experts in head and neck surgery or reconstructive microsurgery.

Finally and most importantly, we hope the head and neck cancer patients will be benefited by the principles and techniques that their physicians apply in their practices from this book.

Taoyuan, Taiwan
September 10, 2017

Ming-Huei Cheng
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Dr. Chang’s academic interests focus on the surgical oncology and translational research on head and neck cancers, including oral cavity cancers and nasopharyngeal carcinoma. He has published more than 150 articles in SCI journals, including several articles published in some prestigious journals such as Nature Communications and Clinical Cancer Research, and serves as the editor and reviewer of many international peer-reviewed journals. Now he is the director of Taiwan Head and Neck Society and also the associate editor of the journal Head & Neck (the top 1 journal in the category of otolaryngology).

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Dr. Kao has over 60 peer-reviewed publications in both top-tier plastic and reconstructive surgery journals and basic science journals. His clinical research largely focuses on the free-flap microsurgical reconstruction of head and neck defects and the functional outcomes seen. His stem cell therapy, with a focus on adipose tissue-derived stem cells in chronic wound healing, has also been making progress in this field. It is his work and translational research that led him to be awarded the 2014 American College of Surgeons International Guest Scholarship Award and the 2013 Excellent Research Award from the Department of Surgery, Chang Gung Memorial Hospital. He also obtained the 2011 Outstanding Thesis Award from the International College of Surgeons for his work.

Dr. Kao and his high value for academic rigor has led him on a relentless pursuit of excellence and, ultimately, developing novel strategies that benefit patients at large. His translational research will soon herald a breakthrough in managing patients with chronic wounds as well as head and neck reconstructions to ultimately bring about change in the way we deal with such conditions.

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Chapter 1
Head and Neck Reconstruction: History, Epidemiology, and Etiology

Shiang-Fu Huang, Ku-Hao Fang, Kai-Ping Chang, and Olivia A. Ho

The practice of head and neck cancer resections and their reconstruction is a particular art and science. While a mastectomy and abdominal defect can usually be closed primarily, there are unique problems with head and neck cancer reconstruction in that there is usually a smaller opportunity for primary closure. Furthermore, when there is a bony defect, the implications on the speech, mastication, and overall appearances make it an additional challenge. There is a difficult task of not only providing coverage but restoring not only the form but the function of the face, jaw, head, and neck.

Some of the earliest literature regarding head and neck reconstruction is known to date back to 1500 BC in India [1]. It was a time when amputation of the nose was a form of punishment and a method to serve justice. The nose is a strong essence of one’s identity and is in a very noticeable location. As such, the practice of this form of punishment propelled the need for reconstructive options to restore this structure. A famous historical illustration demonstrating this humiliating punishment shows Prince Lakshmana amputating the nose of Lady Surpanakha [1].

Soft tissue reconstruction of the head and neck in the pre-free flap area included local skin flaps that have been used for centuries. The earliest documented head and neck reconstruction is arguably the pedicled flap for nose reconstruction described in Sushruta Samhita [1, 2]. A famous historical illustration showing this humiliating punishment shows Prince Lakshmana amputating the nose of Lady Surpanakha [1].

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1794 [2]. The Sanskrit text explained surgical procedures attributed to Sushruta who was a physician in the sixth century BC. In addition to describing nasal reconstruction, it also explained techniques to release the skin for small defect coverage, rotational flap, and pedicled flaps for other areas of the human body than the nose. The paramedian free flap is one of the most recognized local flaps that continue to be used by reconstructive surgeons today.

Up until the nineteenth century, local skin flaps were commonly used. Prior to the 1950s, oral cancer resection defects were generally addressed with primary apposition of the intraoral wound edges and not typically reconstructed [3]. Any reconstruction was not considered until it was clear that there was not any early local recurrence. Bony reconstruction was neither performed at the ablative nor at the delayed reconstruction phase. As a result, the deformity which came to be known as the Andy Gump deformity was common place [2]. During that period, Andy Gump was featured as a televised cartoon character but was apparently based on a real patient. With further research, it was realized that skin flaps can be used if they contained a reliable artery within it which led to the use of axial pattern flaps instead of solely relying on flaps based on a random blood supply. Two main variants that were used in the 1960s that continue to be quite frequently used today include the variant of the forehead flap introduced by McGregor in 1963 and the deltopectoral flap introduced by Bakajiman and Littlewood in 1964 [4, 5].

The 1970s found a more widespread use of distant pedicled myocutaneous flaps such as the temporalis, platysma, sternocleidomastoid, latissimus dorsi, pectoralis major, and trapezius flaps. In 1978, Quillen et al. developed the use of the latissimus dorsi flap for use in the head and neck after it was re-popularized by Olivari in 1976 [6, 7]. In 1968, Hueston and McConchie described the first report of using the pectoralis major flap as part of a compound deltopectoral flap [8–10]. It was Ariyan in 1979 that reported its use in head and neck reconstruction [11]. The pectoralis major flap was rapidly adopted as the commonly used free flap for head and neck reconstruction with later extension of its use by including rib sections to provide bony reconstruction in addition to soft tissue reconstruction [9]. Later, the trapezius flap and its variants became widely used with the inclusion of bone from the lateral clavicle or spine of the scapula.

Prior to the discovery that some pedicled soft tissue flaps can carry bone with its blood supply and prior to the advent of free flaps, bony reconstruction included non-vascularized cortical bone grafts. These grafts were first reported in 1892 by Bardenheuer and were widely used in the First World War [12]. The most common donor sites for these cortical bone grafts were the rib and tibia. In the 1960s, block grafts or particulate cancellous bone in metallic trays most commonly harvested from the iliac crest became popularized [2]. Unfortunately, these were associated with high failure rates due to infection and graft extrusion. In the late 1970s and early 1980s, the development and re-popularization of myocutaneous pedicled flaps described above with the combination with of bone provided surgeons options for bony reconstruction with vascularized bone [2]. However, the bone quality and vascularity of the various combinations such as the serratus anterior with rib; pectoralis major with rib, clavicle, or sternum; and scapula flap with scapular bone were
usually poor. Furthermore, there was limited flexibility for repositioning of the flap. In 1976, Prein et al. described reconstructing a section of resected mandible using a stainless steel plate to span the defect [13]. Up until this point, all the vascularized bone flap options were pedicled. In 1977, Buncke et al. reported the first bone-containing vascularized free flap in the form of a rib free transferred to the tibia [14]. But it was in 1978 when McKee described the first vascularized bone free flap for the purposes of head and neck reconstruction by using a rib segment and transferred to the mandible [15]. In 1986, Wei et al. from Taiwan performed pioneering work in defining the septocutaneous perforators of the peroneal artery that allowed the free fibula flap to be used in complex composite head and neck reconstructions [16]. The first description of the use of the free fibular flap in the mandible was in 1989 by Hidalgo and in 1994 for the maxilla [17].

Various forms of vascular surgery have been undertaken since the mid-1500s. However, the early surgery involved vascular ligature and suture for traumatic battle injuries which later progressed to vascular anastomosis in humans. Certainly, one of the most well-known contributors to the vessel anastomosis techniques is Alexis Carrel who won the Nobel Prize for his work in 1912 [18]. He reported in 1902 the method of attaching blood vessels with the ends rolled backward like a cuff and sutured together using fine needles and sutures that he obtained from a local haberdasher.

The advent of microsurgical reconstruction was made possible after the invention of the microscope. In 1921, the Swedish ear, nose, and throat (ENT) surgeon Carl-Olof Siggesson Nylén built the first operating microscope at the University of Stockholm [2]. In 1922, his colleague Gunnar Holmgren subsequently developed the idea to create a binocular microscope [2]. In the 1950s, Zeiss produced the first modern operating microscope, and then in 1961, Zeiss developed the first diploscope such that two surgeons would be able to see the operating field simultaneously [19].

While the clinical use of the operating microscope was mainly confined to ENT and neurosurgery until the late 1950s and early 1960s, its usefulness was realized by other specialties including plastic surgery. With regard to head and neck reconstruction, it was around this time frame that free flap options began to be used. The late 1950s was also when the first free flaps in humans were performed with the aid of the magnifying microscope. In 1959, Seidenberg et al. used a free jejunal autograft to reconstruct a pharyngeal esophagectomy by anastomosing it to the superior thyroid artery and anterior facial vein using a stapling method [20]. Subsequent work by other surgeons also involved transferring vascularized sections of the gastric antrum and jejunal grafts. In the 1970s, the first reports of free flaps as understood by our current definitions were used. McLean and Buncke used an omentum free flap in 1972 to reconstruct a scalp defect with exposed bone after a squamous cell carcinoma (SCC) resection [21]. The anastomosis performed was of the left gastroepiploic artery to the superficial temporal artery, and the omentum flap was then covered with a meshed split-thickness skin graft. Later in 1972, that same year, Harii et al. used the first reported free skin flap for head and neck reconstruction by using a temporal flap based on the superficial temporal artery and moved to another
scalp location for the purpose of resurfacing an area affected by alopecia [22]. Subsequent reports of free tissue transfers to oral and maxillofacial regions soon followed. In 1973, Kaplan et al. reconstructed an oral cavity defect with a free groin flap [23]. As surgeons became more experienced, articles published included more patients. In 1974, Harii et al. reported oral cavity defect reconstruction using deltopectoral flaps, and in 1976, Panje et al. published results of using free groin flaps for head and neck cancer ablation reconstruction [24, 25]. In 1978, the radial forearm fasciocutaneous flap was developed by Guofan, Baoqui, and Yuzhi at the Shenyang Military Hospital in China. It was then reported by Yang et al. in 1981, who used it to treat neck burn contracture [26]. The radial forearm flap became known as the “Chinese forearm flap” when it was described in Western publications in 1982 by Song et al. and Muhlbauer et al. [27, 28].

In the mid-1970s to late 1970s, free flaps were used in reconstruction by plastic surgeons in various diverse applications ranging from defects from the head to toe [2]. However, in the 1980s, there was again a resurgence of re-popularizing the pedicled myocutaneous flaps as there were a limited number of head and neck surgeons who could perform free flaps and they found the pedicled flaps were easier and faster to harvest and required only one stage and one team. The situation again reversed in the 1990s when free flap techniques advanced and became the dominant reconstructive method for head and neck reconstruction after cancer resection and large traumatic defects. From the 1990s to the present time, free flap reconstruction of the head and neck is commonplace, and new technology and advances in training further ease its use and secure its position in the armamentarium of today’s surgeons.

In Taiwan, the incidence of head and neck cancer ranked the fifth in male cancers and continues to rise (Fig. 1.1) [29]. The incidence of oral SCC in Taiwan and other Asian countries is high due to the consumption of cigarette and alcohol and areca quid (AQ) chewing [30]. Predisposition of cancer is often a complex societal, cultural, and environmental amalgam. In oral cavity cancer patients, cigarette smoking or areca quid chewing is commonplace in interaction during work especially among taxi drivers. The median age of head and neck cancer occurrence in Taiwan is between 40 and 50 years old and can arise in various areas of the oral cavity (Fig. 1.2) [31]. The prevention and treatment of head and neck cancer is important because it is both a medical and a social issue.

The use and abuse of tobacco products is the major cause of head and neck cancer [32–34]. Head and neck cancer risk was elevated for those who reported exclusive cigar smoking (odds ratio 53.49; 95% CI 52.58–4.73) or exclusive pipe smoking (odds ratio 53.71; 95% CI 52.59–5.33) [10]. Alcohol use synergizes with tobacco as a risk factor for upper aerodigestive tract SCCs where this synergism is more evident in the cancer of the mouth [35]. Determining the independent effects of these habits is difficult, because these habits usually overlap. Although possibly imprecise, the risk was particularly evident for laryngeal cancer (sixfold for every cigar smoking and 3.5-fold for every pipe smoking) and hypopharyngeal cancer (fourfold for every pipe smoking) [36].

AQ is prepared from areca nut, cured or sun dried, and chopped where the customs vary widely. These pieces are placed on a leaf of the Piper betle vine (in most
Fig. 1.1 Head and neck cancer incidence and mortality rate according to different subsites in Taiwan over a period of 12 years (1999–2010). The number increases most prominently in oral cavity cancer.
parts of the world where the habit is indigenous), and the inflorescence is used by some, such as Guam and Papua New Guinea [37]. Slaked lime is an essential ingredient which lowers the pH and accelerates the release of alkaloid from both tobacco and nut, with enhanced pharmacological “lift.” The areca quid used in Taiwan contains areca (betel) nut, slaked lime, catechu, *Piper betle* inflorescence, or *Piper betle* leaves. This combination is different from that consumed in other countries in three aspects: Firstly, tobacco is not included in the chewing of AQ. Secondly, fresh *Piper betle* inflorescence is added to AQ for its aromatic flavor [37]. Thirdly, fresh and tender areca nut with husk is used in AQ chewing in Taiwan as compared with the ripe and husk removed areca nut used in other countries [38]. The effects of long-term, heavy chewing on the mouth are characteristic and are shown in Fig. 1.3a, b.

The mechanism of the content of AQ is quite complex. Areca nuts contain potent cholinergic muscarinic alkaloids, notably arecoline and guavacoline, with a wide range of parasympathetic mimetic effects: they promote salivation and the passage of wind through the gut, raise blood pressure and pulse rate, and elicit a degree of euphoria by virtue of their γ-aminobutyric acid (GABA) receptor inhibitory properties, which contribute to dependence and habituation. There are also bronchoconstrictor effects and evidence for a role in precipitating and exacerbating asthma and diabetes [39]. There were also reported seeking pharmacologically addictive stimulants from AQ or from tobacco to keep awake or to relieve stress [40–42].

Areca nut is the main etiological agent causing oral submucous fibrosis [43]. However, in patients with concurrent submucosal fibrosis and oral cancer, most of them use both AQ and tobacco. As seen from studies in the Indian subcontinent, the addition of tobacco to AQs increases their risk of submucosal fibrosis. Evidence from elsewhere in the world (e.g., South Africa) is conflicting. Studies have even found that betel leaf itself has been shown to have a protective effect [44], and at least two protective compounds have been identified β-carotene and hydroxychavicol (an astringent antiseptic). It is now shown that AQs without tobacco are also associated with oral cancer. The International Agency for Research on Cancer (IARC) determined in 1985 and 2004 that “Betel quid (BQ) without tobacco causes oral cancer (only), while BQ with tobacco causes oral cancer, and cancer of the pharynx and esophagus” [45, 46].
More than 90% of malignant neoplasms of the head and neck are squamous cell carcinoma (SCCHN) of the lining mucosae with relatively rare neoplasms arising in minor salivary glands and soft tissues. Although the differentiation (well, moderately, or poorly differentiated) of squamous cell carcinoma has been regarded as no impact on prognosis after treatment, our group first discovered that poorer tumor histological classifications of oral squamous cell carcinoma are significantly associated with positive nodal status, extracapsular spread, perineural invasion of primary tumors, and the probability of developing neck recurrence and distant metastasis after treatment [47]. To improve health care in head and neck oncology, scientific discoveries must be translated into practical applications. Although there are currently no useful blood markers for detecting SCCHN or monitoring the tumor relapse clinically, in our previous publications, we have found that the blood levels of C-reactive protein and squamous cell carcinoma antigen are positively associated with higher TNM stage and useful in the risk stratification of SCCHN [48–50].

The historical evolution of head and neck reconstruction has certainly taken great strides throughout the last several centuries. This book aims to provide a comprehensive resource to head and neck reconstruction ranging from the principles of surgical resection and preoperative planning to reconstruction of the various subsections of the head and neck region including the intraoral and tongue, mandible, maxilla, skull base, pharyngoesophageal, and nasal reconstruction. Furthermore, methods to achieve success in revisional and secondary procedures are explored. Finally, the future of the growing field of vascularized composite allotransplantation is covered. We hope you will find this a useful compendium for your studies and clinical practice.
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Chapter 2
Basic Principle of Resection for Head and Neck Cancer

Ku-Hao Fang, Shiang-Fu Huang, and Kai-Ping Chang

Introduction

Treatment options for the management of head and neck cancer include surgery, radiation, chemoradiotherapy, or a combination of these treatments. This chapter focuses on basic principles of the surgical resection for head and neck cancers. The challenge of ablative surgery of head and neck cancers is to perform an adequate resection while providing the best functional reconstruction. Adequate resection of the primary tumor, eradication of regional lymph nodes, and successful reconstruction are the key to most efficacious treatment for head and neck cancer. The following section would discuss some surgical details including approach/incision and resection concepts according to subsites of head and neck cancer.

Cancer of the Buccal Mucosa

The buccal mucosa, as defined by the American Joint Committee on Cancer (AJCC), “includes all the membrane lining of the inner surface of the cheeks and lips from the line of contact of the opposing lips to the line of attachment of mucosa of the alveolar ridge (upper and lower) and pterygomandibular raphe” [1]. The cheek plays an important functional and aesthetic role. Contraction of the buccinator muscles compresses the cheeks and positions food over the occlusal surfaces of the teeth.
which are important in mastication. The abrasion and irritation of buccal mucosa during chewing areca quid (AQ) make the occurrence of buccal cancer being higher in AQ endemic area than others. A fascial space is termed the buccal space. The anatomic boundaries of the buccal space are as follows: posterior, the masseter muscle; anterior, orbicularis oris muscle; medial, buccinator muscle; lateral, muscles of facial expression and superficial fascia; superior, zygomatic arch; and inferior, mandible [2]. Normal cheek appearance and contour rely on the fullness provided by the buccal fat pad, the skeletal support of the zygoma and mandible, and the baseline tonicity provided by the confluence of several muscles innervated by the facial nerve. The buccal fat pad (also named Bichat’s fat pad) provides cushion during our mastication. The volume of the fat pad remains relatively stable throughout a person’s life [3]. Structures superficial to the buccal mucosa include the facial expression muscles, artery, vein, nerve, and skin. The facial nerve innervates the mastication and facial expression muscles. Treatments for cancer of the buccal mucosa such as full-thickness cheek resection often disrupt the balance between function and aesthetics. The sacrifice of facial nerve branches or even skin usually leaves irreversible damage which is hard to be restored. However, in buccal cancer patients, the over-concern of function or aesthetic usually compromises the implement of radical surgeries.

Cancers arising from the labial vestibule tend to invade the adjacent perioral musculature and mandible, and the pattern of invasion dictates management. In buccal cancers, the locoregional control can be achieved by radical surgeries followed by adjuvant radio- and/or chemotherapy [4]. However, distant metastasis rate is still higher than tongue cancer in patients with positive lymph node metastasis [5, 6].

The extent of tumor resection is dictated by combining clinical examination with radiologic assessment by MRI (Fig. 2.1) or CT. Panoramic radiography also provides a good guidance of the tumor invasion (Fig. 2.2). The extent of buccal tumor involvement usually presents to clinicians with three different conditions: (1) superficial lesions that are not fixed to the underlying musculature should undergo resection that includes the buccinator muscle as the deep margin; (2) lesions that invade deeper through the buccinator muscle should be considered for resection of the buccal space; and (3) tumors with extensive buccal space involvement or that invade into the soft tissues lateral to the buccal space should require full-thickness resection with wide margins and intentional sacrifice of the facial nerve branches in this region (Fig. 2.3). The thickness of the buccal mucosa to skin is pyramidal in shape from posterior to anterior (Fig. 2.4). In an analysis of 30 middle-aged male patients in our institute, the anterior buccal mucosa-to-skin mean thickness is 9.7 mm, whereas the posterior part (in the second molar region) is 25.1 mm. Surgeons are prone to compromise the deep margin of resection to avoid injury to the facial nerve and the need for reconstruction of a full-thickness defect. In anterior-located buccal cancer, the buccinator muscle involvement has been documented in more than 60% of stage I or II tumors, so the buccinator muscle should be respected as the deep surgical margin for superficial lesion [7].
In our hospital, we will sacrifice skin if the distance between deep margin of tumor and skin is less than 5 mm on CT or MRI. Extension into the buccal fat leads to unpredictable patterns of tumor invasion because there are no good anatomic barriers to spread. Full-thickness cheek resection should be considered when there are radiographic or clinical evidence of invasion through the lateral aspect of the fat pad or the buccal space. Facial nerve preservation should not be attempted unless an oncologically safe en bloc resection can be accomplished. Facial nerve dissection may be occasionally performed to preserve the nerve functions. Deeply infiltrating tumors that extend close to the skin or manifest facial nerve weakness require full-thickness cheek resection without regard for the reconstructive implications. In Taiwan, due to the use of AQ, buccal cancers could have concurring submucosal fibrosis. It makes the preoperative examination difficult. Most of the time, the extent of tumor relies on the imaging studies. In addition, the cheek flap is needed due to the limited exposure of oral cavity from the submucosal fibrosis.

A retrospective review by Bloom and Spiro [8] noted that 67% of T1 lesions and 31% of T2 lesions could be resected by transoral resection without a cheek flap. In
Diaz’s study, 73% of the lesions could be resected transorally, whereas 27% required a cheek flap. In our institute, T2 or more advanced lesions were usually resected by a cheek flap for better surgical exposures.

When the border of buccal cancer is close to the gingiva-buccal sulcus, it should be carefully inspected that the bone cortex of mandible or maxilla is involved or not. For safety margin concerns, if the lesion abuts the sulcus, we will perform marginal mandibulectomy or inferior partial maxillectomy which depends on the location of tumor. For lesions that directly invade and destruct the mandible, segmental mandibulectomy will be done.

In a recent review of buccal mucosa cancers, resection of the mandible was required in 23% of the cases, and partial maxillectomy was performed in 16% [9]. Ten percent of the resultant defects required free tissue transfer, and mucocutaneous flaps were used in 6%, whereas regional skin flaps were utilized to close 3% of the defects. However, for better cosmetic and functional recovery after surgeries, free tissue transfer reconstructions are usually adopted in our institute in the recent years which will be discussed later in the reconstruction section.

**Alveolar Ridge Cancers**

The performance of mandibular conservative surgery must account for particular patterns of tumor invasion and variations in mandibular bony anatomy that can impact the eventual oncologic and functional result. Segmental mandibulectomy...
should be considered the procedure of choice in patients with suspected mandibular bone invasion whenever less aggressive surgical resection could compromise local-regional control (Fig. 2.5a, b).

At surgery, the periosteum can be elevated from the mandible where the tumor abuts the mandible but not invades the periosteum. And the resection margin could be extended deep to the level of soft tissue invasion. For tumors that appear to be fixed to the periosteum but the presence of mandibular invasion could not be determined via preoperative imaging studies, periosteal stripping could be an effective maneuver in this situation [10]. However, it must be cautiously utilized because the risk of residual microscopic disease following resection.

The performance of a conservation mandibulectomy procedure must preserve a biomechanically stable mandible that can withstand the load-bearing forces created by mastication. Bartelbort et al. investigated on fresh cadaveric mandibles and found that the strain significantly increased when the height of the residual mandible was reduced from 10 mm to 5 mm. It suggests that at least 1 cm of the mandibular bone is necessary to prevent pathologic fracture [11].

The marginal mandibulectomy for the alveolar lesions that involve the floor of the mouth or lingual mandibular gingiva needs a circumferential mucosal incision. The incisions should be made at least 1 cm from mucosal abnormalities. Marginal
mandibulectomy can be executed below the apices of the tooth roots. A subapical osteotomy that is inferior to the molar root apices could possibly damage the inferior alveolar nerve. If a transverse osteotomy would be done and not to transect the dentate portion, dental extractions are necessary. For edentulous mandibles, special caution should be taken during osteotomy. Inadvertent straining of mandible will fracture the mandible. When the tumor extends into surrounding soft tissues, then genioglossus and mylohyoid muscles could be sacrificed for adequate soft tissue margins.

In situations where the tumor is fixed to the periosteum and early cortical invasion cannot be excluded, a marginal or sagittal mandibulectomy can achieve a resection that extends at least one anatomic plane deeper than the anticipated depth of tumor invasion. The design of composite procedure should be dictated by the three-dimensional configuration of the tumor as determined by clinical exam and radiographic findings. Based on the evidence that spread within the medullary cavity typically extends no more than 1 cm from the region of overlying mucosal abnormality and the site of bony invasion, a safe tumor-free margin can usually be attained by resecting 2–2.5 cm of additional mandibular bone. Segmental resection should be considered whenever there is any suspicion of more than early cortical invasion in the nonirradiated mandible and whenever mandibular invasion of the irradiated mandible is suspected.

**Retromolar Trigone Cancer (RMC)**

The retromolar trigone anatomically is close to the ascending ramus of mandible and pterygoid muscles in its deep part. RMCs were routinely treated by posterior segmental mandibulectomy or composite resection [12]. Byers et al. [13] previously described resection of “a margin of bone including the coronoid process resected with the retromolar trigone cancer.” For early cortical invasion of the RMC, posterior marginal mandibulectomy with coronoid process resection can be a more
conservative option. Inclusion of the coronoid process is usually necessary for an adequate bone margin. In AQ-chewing OSCC patients, trismus was frequently met. It should be careful that the presence of trismus might be secondary to significant masticatory muscle invasion. The condition could possibly contraindicate conservative surgical resection.

A cheek flap or a lip-splitting incision in combination with a cheek flap may be necessary for more extensive resections that involve the buccal mucosa, maxilla, or soft palate or in cases where trismus precludes adequate exposure.

When coronoidectomy is incorporated into the resection, an incision is extended posteriorly, immediately superficial to the underlying ramus. Dissection is continued through the soft tissues down to the ascending ramus, where subperiosteal dissection is performed up to the coronoid process and the attachments of the temporalis muscle are released.

Surgical resection of advanced RMC lesions was transcortical invasion into the medullary cavity, which typically requires an extensive resection of the mandible, masticatory muscle, tonsillar fossa, and soft palate. Barbosa [14] ever described that for advanced RMC, the resection should consist of hemimandibulectomy with the masseter and pterygoid muscles in continuity with an ipsilateral radical neck dissection. Kowalski et al. [15] reported the routine sacrifice of the condyle and 3 cm of bone anterior to the anterior-most border of gingival or mandibular involvement. Buccal or RMC cancers that tumor invades posteriorly into the masticatory space were staged as T4b lesion. Liao et al. reported the surgical treatment results in our institute. If the border of buccal or RMC cancers is below mandibular notch, it could have a 5-year disease-free survival at 64.7% after the radical surgeries [16, 17].

Cancer of the Tongue

Tongue cancer may be treated by transoral approach, pull-through approach, or mouth floor release approach with visor flap. Only when the patients have severe trismus (inter-incisor distance less than 2.5 cm or 1 in.) caused by submucous fibrosis in betel quid chewing prevalence area or other reasons that the mandibulotomy approach is needed in acquiring adequate exposure. The mandibulotomy approach could be performed either midline or paramidline [18]. When the tumor invades the mandibular bone, the mandibulectomy procedure is indicated. The tumor usually invades the mandible through dental socket rather than directly through the periosteum, and, thus, marginal mandibulectomy usually could obtain oncological need to preserve mandible continuity (Fig. 2.6). However, when both mandibulotomy and marginal mandibulectomy are needed, segmental mandibulectomy with reconstruction is preferred to prevent complications such as osteoradionecrosis of the mandibular bone [19]. Table 2.1 shows the general principles of management of tongue cancer by approach-resection-reconstruction.
**Fig. 2.6** (a) Surgical defect in a patient who has undergone lip splitting and hemiglossectomy with marginal mandibulectomy. (b) Synchronous three tumors of the tongue and lower gum

**Table 2.1** Surgical approach, resection and reconstruction for cancer of the tongue

<table>
<thead>
<tr>
<th>Approach</th>
<th>Resection</th>
<th>Reconstruction</th>
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<tr>
<td>Transoral</td>
<td>Less than hemiglossectomy or dorsal surface cancer</td>
<td>Primary repair or STSG</td>
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<tr>
<td>Pull through</td>
<td>Hemiglossectomy to preserve at least contralateral hypoglossal nerve</td>
<td>Free flap</td>
</tr>
<tr>
<td>Mouth floor release with visor flap</td>
<td>Total glossectomy</td>
<td>Free flap</td>
</tr>
<tr>
<td>Mandibulotomy (midline versus paramidline)</td>
<td>For severe trismus (inter-incisor distance less than 2 cm)</td>
<td>Free flap</td>
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<tr>
<td>Mandibulectomy (marginal versus segmental)</td>
<td>Marginal mandibulectomy is indicated if the tumor is also noted on the alveolar ridge; segmental mandibulectomy is suggested if both mandibulotomy and marginal mandibulectomy are needed for the surgical approach</td>
<td>Free flap reconstruction plate + free flap or free fibula flap</td>
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<td>Combine with laryngectomy</td>
<td>Advanced tumor invades pre-epiglottic space</td>
<td>Free flap</td>
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