AN ALTERNATIVE APPROACH TO COMPLICATED PROCEDURES - SHORT DENTAL IMPLANTS: A REVIEW OF LITERATURE

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ABSTRACT

Success rates for endosseous dental implants are high. While historically implants were of standard lengths and diameters, implants increasingly became available that were shorter or longer and with wider or narrower diameters, as well as with varying macro-geometric designs. Anatomical considerations may exist that require either adjunctive treatment prior to implant placement or, instead, the placement of short implants.

Recent research has found that length, macro-geometric design and diameter influence the amount of bone that osseointegrates due to differences in surface area, as well as the distribution of forces and resulting stresses. With appropriate selection, high success rates can be enjoyed for both long and short implants where indicated.

KEY WORDS

endosseous, macro geometric, implants

INTRODUCTION

The Goal of modern dentistry is to restore the patient to normal contour, function, comfort, esthetics and speech. With the introduction of osseointegration concepts of Branemark, the use of dental implants in treatment of complete and partial edentulism has become an integral treatment modality in restorative dentistry.[1]

The placement and restoration of endosseous dental implants have become routine dental procedures that offer high success rates when suitable planning and protocols are followed. Patients now routinely ask for implants as they hear about the results that can be achieved both for function and esthetics.

Modern implant treatments had their genesis in treatment that involved the placement of hollow baskets in the jaw bone. The first truly modern endosseous (root form) implants were introduced in the 1980s and heralded improved treatment options and outcomes for patients and clinicians.[2] Initially, the required implant length was considered to be between 10 and 13 mm to allow for adequate osseointegration of a sufficiently large area and for strength. This was also regarded as a suitable length that would respect anatomical structures in most patients.

Over time, alternative lengths and diameters were introduced in response to clinical demands: first, narrower and longer length implants, then shorter implants with wider diameters and later, shorter implants with a modified form.[3]

ANATOMICAL CONSIDERATIONS FOR IMPLANT PLACEMENT

Adjacent anatomical structures are key factors in the planning and placement of dental implants. In both the maxilla and mandible, the height and width of available alveolar bone is crucial; when a relative insufficiency of bone is present, implant positioning may be suboptimal to compensate for the lack of adequate bone. In addition, bony undercuts can lead to perforation of the cortical bone during preparation of the osteotomy and/or lead to suboptimal implant placement,[4,5] and the apices of teeth may be very close to a proposed osteotomy site. Beyond this, there are specific anatomical factors to consider for each arch.

Maxillary Arch: Maxillary sinus, nasal floor, nasopalatine canal, mandibular arch: inferior dental canal position, presence of bifid inferior dental canal, interforamenal area, presence of accessory mental foramena, presence of a neurovascular incisive canal, presence of anterior looping of the mental nerve, lingual foramena positions

In Patients with advanced levels of alveolar bone resorption, a provision of dental implants is often problematic and may require additional surgical intervention to augment bone levels. This is particularly seen in the posterior maxillary and mandibular regions, where there is risk of involving the inferior alveolar nerve or penetrating the maxillary sinus during the implant placement when the alveolar bone is deficient. This requirement for additional surgery adds considerably to the treatment duration and costs may deter some patients from undergoing prosthetic rehabilitation.[6]

An alternative approach in such cases when a limited amount of bone is available is to use short implants, 6 to8 mm in length instead of the standard range of 10 to 16mm. This strategy avoids the need for bone augmentation procedures and simplified treatment.[7-10]

A number of publications have reported poorer outcomes for shorter machined implants compared with longer ones. In contrast however some investigators found that implant length does not significantly influence the outcome for implants with textured surfaces.[3,11,12]

Several dental health criteria have been adapted for implants. The clinical criterion most commonly reported is the survival rate, or whether the implant is still physically in the mouth or has been removed

Criteria for implant success (Albrektsson T, Zarb GA, Worthington P et al)

- An individual unattached implant is immobile when tested clinically.
- The radiograph does not demonstrate any evidence of periimplant radiolucency.

- Vertical bone loss is less than 0.2 mm annually after the first year of service of the implant
- Individual implant performance is characterized by an absence of persistent or irreversible signs and symptoms such as pain, infections, neuropathies, paresthesia, or violation of the mandibular canal.
- In the context of the foregoing, success rates of 85% at the end of a 5-year observation period and 80% at the end of a 10-year period are minimum criteria for success.

If implant mobility occurs at placement, options available to correct this problem include

1. The use of an HA coated implant
2. Use of wider diameter implant
3. Use of longer implant.

Langer et al proposed the use of 5.0 or 5.5 mm diameter implants

a) to gain implant stability at time of placement in jaw regions where low density bone is common
b) avoid damage to inferior alveolar canal or the maxillary sinus where there is inadequate bone available for implant placement
c) resolve complications involving failure or removal of an implant that did not integrate or was damaged

The use of 5mm diameter implant that is 6mm long increases the surface area available to contact the similar to that of a 3.75mm diameter implant that is 10mm in length. To reduce the risk of failure of end osseous Implants used for posterior applications wide diameter implants have been suggested. When sufficient bone is available placement of wide diameter implant is considerably easier than placement of two implants.

It has long been a proposition in implant dentistry that as many as implants as possible of maximum length should be used. Advantages of increased implant length increased initial stability, long term resistance to bending moment forces, expedited healing and decreased risk of movement at the interface. The number of implants required depends on type of prosthesis, bone quality and location. Restorations supported by multiple implants generally perform better as compared with those supported by fewer implants. When reasons for implant failure during function are evaluated, length and diameter must be taken into consideration.

REVIEW OF LITERATURE

Early Research Studies

An early review by Goodacre et al. of short implants reported in clinical studies between 1981 and 1997 found a higher failure rate and implant loss with short implants than with long implants,[13] while Sennerby and Roos found a higher failure rate with poor bone quality and short implant placement in the atrophic maxilla or following bone-grafting procedures or irradiation.[14] Winkler et al. also compared short and long implants as well as narrow- and wide-diameter implants. They did not assess any other variables but found shorter implants and narrower-diameter implants had a lower survival rate.[15]Olate et al. retrospectively assessed the survival rate of 1649 acid-surface-treated titanium cylindrical implants ranging from short (6 to 9 mm) to long (13 to 18 mm) in length that were placed in 650 patients (mean age 42.7 years). The researchers concluded that shorter implants were more likely to result in failure than longer implants were but found no differences associated with the diameter of the implants or with bone quality. However, they also concluded that the findings could have been due to the operator's experience or changes in technique and indications for short implants in the eight years preceding 2004.[16]Friberg et al. also found a high success rate for short implants, with a 95.5% five-year survival rate.[17] An earlier report published in 1998 by ten

Bruggenkate et al. reported on 253 short implants of 6 mm length with a follow-up of one to seven years, with the investigators finding a six-year survival rate of 94% and concluding that the quality of survival was comparable to that of longer implants.[18] Gentile et al. retrospectively compared the one year survival rate for implants measuring 6 mm in length and 5.7 mm in diameter with those of the same diameter but longer in length, finding their survival rates to be comparable (failure was defined as explantation of the implant).[19] Venuleo et al. compared the survival and success rates of implants of varying lengths and diameters, all of the same design. The lengths varied from 6 to 14 mm and the diameters from 3.5 to 6 mm. In addition, uncoated, titanium plasma-sprayed and hydroxyapatite-coated implants were researched. It was found that the five-year survival rate of the 6 mm by 5.7 mm implants was 100% with a mean bone loss of 0.03 mm, which was statistically comparable to the longer implants with the same design.[20]

Recent Pre-2010 Published Studies and Reviews

A 2009 retrospective study by Grant et al. involved 335 implants 8 mm in length placed in the posterior mandible in 124 patients (median age 56 years and 112 partially edentulous). The majority received fixed prostheses, while the remaining subjects received individual restorations. Four implants (in two patients) failed to osseointegrate, and one implant fractured. Of the remaining 330, for up to two years post-placement the survival rate was 99%. The investigators concluded that the placement of short implants was predictable and a suitable treatment for patients with reduced bone height in the posterior mandible.[21] A meta-analysis by Kotsovilis et al. of 37 English language articles on studies conducted and published up to August 2007 compared the survival rates for short (<8 mm or <10 mm) and longer rough-surface implants in partially or fully edentulous patients. They concluded that short rough-surface implants were as effective as longer, standard rough-surface implants in both partially and fully edentulous patients.[22] Malo et al. published their prospective study in 2007 on 237 patients who received 408 short (7–8.5 mm) implants (131 7 mm; 227 8.5 mm). Restoration and loading occurred four to six months following implant placement.The cumulative survival rate was found to be 96.2% for 7 mm implants and 97.1% for 8.5 mm implants at five years, with a follow-up period ranging from one to nine years.[23] Romeo et al. compared either sandblasted large-grit acid-etched and titanium plasma-sprayed implants of 8 mm and 10 mm in length placed over a 14-year period in 129 patients, finding no differences in their survival rate in the 106 patients who completed the study. The cumulative survival rates were over 97% in both cases, with no differences in mean marginal bone loss or gingival crevice probing depths.[24]

2010 Published Studies and Reviews

Anitua and Orive reported on 1287 implants less than 8.5 mm in length placed in 661 patients between 2001 and 2008, finding a 99.3% implant survival rate with a mean follow-up period of 47.9 months and concluding that short implants are safe and predictable.[25] Another study published by Koo et al. in 2010 reported on 489 patients with a mean age of 47 years (range, 23–91 years), 32 of whom received two implants, while all other subjects received single implants. Implants were placed in maxillary and mandibular arches in these patients. The cumulative one-to-five-year survival rate was 95.1% with no statistical difference between maxillary and mandibular placement, one or two-stage implants, or short or long implants. The short implants were less than or equal to 8.5 mm in length; the long implants greater than 10 mm in length. The respective cumulative survival rates were 100% and 95.1%.[26]. Similarly, a 2010 review by Romeo et al. of 13 studies led to the conclusion that any differences in survival rates were statistically insignificant and that short and standard implants have similar survival rates. The researchers also concluded that treatment planning must fully assess the site and implants, including but not limited to the implant site and bone quality as well as the crown-to-implant ratio of the final prostheses. The review excluded studies involving medically compromised patients or patients with untreated periodontal disease and nonhealed ridge sites.[27]

Private Practice Setting Studies

Several studies have also assessed the success rates for shorter implants placed in private practice settings. Fugazzotto retrospectively assessed 2073 short implants ranging in length from 6 to 9 mm, placed in 1774 patients in a clinical practice setting. Depending on the site, the cumulative survival rate was between 98.1% and 99.7%.[28] Arlin reported on 630 implants placed in 264 patients between April 1994 and December 2003 in a private practice setting. The two year survival rate for the 6 to 8 mm implants combined was equivalent to the 10 to 16 mm implants (although there was a slightly lower survival rate for the 6 mm than for the 8 mm implants). He concluded that short implants were predictable in patients with limited bone availability and that ridge augmentation was not required.[29]

DISCUSSION

Based on the many studies conducted, we can see the stability of the rough-surface implants after a 6-year follow-up, as opposed to the downward trend with implants that have a smooth surface. The machine-surface implants, however, follow this progressive decline according to how the follow-up period increases, passing from an initial approximate percentage of 96% on average for all of the 1-year follow-ups, to 92.9% at 6 years.[30]

The macro-geometric design and diameter of implants have been found to be relevant for applied forces and stress. Logically, increases in diameter increase the surface area of the bone-implant interface and thus an increase in diameter could compensate for decreased length. Other factors that increase surface area of the bone-implant interface include the presence of rough surface areas and plateaus (fins)[31]. Himmlova et al. found that an increase in the diameter of implants was associated with reduced stress at the implant neck and good distribution of force compared to increases in implant length.[32] Pierrisnard et al. found in their study that the stress to which implants were exposed increased as the length of the implant increased (range, 6 to 12 mm) while the maximum bone stress was found to be almost constant.[33]

Physics and the distribution of forces self-evidently dictate that the majority of the force and compression at the implant bone interface occurs in specific areas of its length; the middleof the implant's length is a wasted area with respect to the distribution of forces. Logically, therefore, it is the availability of sufficient area where the forces are distributed that is important, rather than the total length of an implant. Nonetheless, if implants are short and also of very narrow diameter, they are at risk for implant failure, implant component fracture or other complications with repeated application of forces, particularly in the posterior maxilla or mandible. On the other hand, the area exposed to force and compression can be increased by roughening the surface and/or employing a macro-geometric design that provides for a favourable shape.

The implant-crown relationships that exceed the ratio 1:1 are harmful for any implant [34,24] It is logical to think that a short implant falls into this category in many instances, which is why special care must be taken when developing the patient's occlusal pattern once reaching the prosthesis stage of rehabilitation, avoiding contact in lateral movements. The placement of a greater number of implants is also a good solution for offsetting an unfavourable crown-implant ratio, given that it considerably decreases the stress placed on the bone surrounding the implants

Urdaneta retrospectively analysed 81 patients who had received a total of 326 locking-taper implants with cement-free restorations, with a mean follow-up period of just under six years. The crown-to-implant ratio had a range of 0.79 to 4.95, with implant restorations having a ratio equal to or greater than 2. It was concluded from the research that a crown-to-implant ratio of up to 4.95 had no effect on crestal bone loss, nor was this associated with an increased risk of implant failure or crown failure, although more restorative complications were observed.[35] A second retrospective study of the same implant type in 294 patients receiving at least one single tooth implant, and with a mean follow-up period of 2.3 years (and up to 7.4 years), led to the conclusion that implant success or failure was not related to variations in the crown-to-implant ratios.[36]

SUMMARY AND CONCLUSION

Endosseous dental implants have revolutionized the fields of implants. Implant placement is a viable option in the treatment of partial and full edentulismand has become an integral facet of dental therapy. Shortimplants offer a viable and successful alternative in patientswho would otherwise require adjunctive treatment such asbone grafting prior to placement of a longer implant. Thismay also lead to greater case acceptance due to the treatmentbeing less invasive, less expensive and less daunting for thepatient. The placement of short implants in these situationsalso enables dentists to place the implant where a referralwould otherwise be necessary due to the requirement foradjunctive treatment. The factors in the success of short implants include Osseointegration, macro-geometric design, physics and the distribution of forces and finally the diameter of the implant. Research now provides extensiveevidence for the high success rates that can be achieved withboth long and short implants as well as for the importance ofan appropriate design.

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APPLICATIONS OF ENDOSCOPY IN CRANIOMAXILLOFACIAL TRAUMA- A REVIEW

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ABSTRACT

Endoscopy has evolved as a discipline as a result of surgical innovation and new technology. During the past decade there has been great interest in minimally invasive surgery and the application of endoscopic techniques in the craniomaxillofacial region. Management of maxillofacial trauma, orthognathic procedures, sialoendoscopy and temporomandibular joint surgery are commonly performed with the assistance of the endoscope. Endoscopic approaches in maxillofacial trauma have been used in the repair of fractures of the zygomatic arch, orbit, frontal sinus, condyle and angle of mandible.

KEYWORDS

Fracture, mandibular condyle, orbital floor, frontal sinus, zygomatic arch.

INTRODUCTION

Endoscopy literally means to look inside (origin:<gk comb. form ofendon meaning within +skopIa meaning watching), typically referring to looking inside the body for a medical purpose with an endoscope. Modern endoscopes(Fig 1 A and B) consist of a rigid or flexible tube with a light delivery system usually composed of fiber optics to route light from an external source to the area of interest. There is a system of lenses in rigid endoscopes that transmit the image to an eyepiece or video camera for the surgeon. Most flexible endoscopes rely on a coherent optical fiber system to transmit the image. Many endoscopes will also have channels for irrigation, suction, or the introduction of surgical instruments.[1] Phillipbozzini is credited with the first major endoscopic advancement to improve illumination.[2]

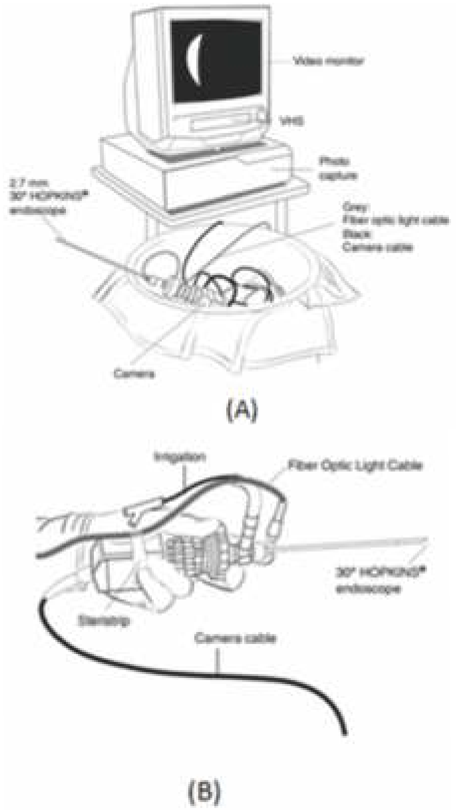

Fig1(A) and (B): Parts of endoscope

The first application of the endoscope in craniomaxillofacial surgery was for aesthetic procedures such as brow-lifting,[3, 4,] 5procerus resection,5and forehead recontouring.[6,]7The introduction of endoscope to facial trauma care has allowed surgeon to achieve laudable goal of stable anatomic reduction while taking maximal advantage of minimal access approaches.[8]

In the overview to follow, the application of endoscope assisted techniques in the management of fractures of the mandibular condyle, orbital floor, frontal sinus,and zygomatic arch is presented.

APPLICATIONS

Fractures of Mandibular condyle

Fractures of the mandibular condyle are common and account for 9–45% of all mandibular fractures.[9, 10, 11, 12] A variety of options have been described to treat these fractures, including closed and open treatment involving a variety of surgical approaches. Each treatment has its advantages and disadvantages depending on the level of the fracture and the degree of displacement.[13, 14, 15] Because of the possible complications, the indications for open reduction or closed treatment remain controversial. The endoscope allows the restoration of normal condylar anatomy minimizing the risks of open treatment. Exposure and fixation of the fracture intraorally avoids crossing the course of the facial nerve.[8] There have been two approaches to the ramus condyle unit described for sub condylar fractures: 1) intraoral[16] and 2)extraoral.[17, 18, 19, 20]

The intra oral approach is solely recommended for treatment of low condylar fractures due to the restricted surgical field and limited access to the condylar neck.[21]

In the intra oral approach a 4cm mucoperiosteal incision is given. The mucoperiosteal flap is elevated and retracted with a long langenbeck retractor and an optic light retractor in the angular region until adequate visualization of the condylar fracture is possible. The fracture is reduced with the assistance of longer clamps, the reduction verified by direct visualization. Two 2.0-mm plates and screws are used for fixation with help of a 90-degree angled screwdriver (Fig 2). The first plate installed in the posterior border and the second in the anterior border.[21]

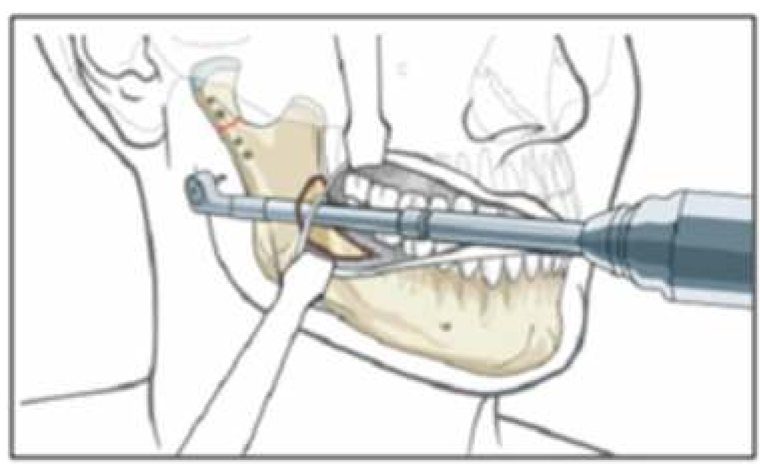

Fig2: Ninety degree angulated drill operation handout

In the extra oralapproach a 1.5 cm incision (Fig 3), 1fingerbreadth below the angle of the mandible is made. The dissection is carried bluntly through the tissue planes, stretching in the direction of the facial nervefibers. Once the masseter muscle is reached, a needlepoint electrocautery is used to incise down to the mandibular angle. With endoscopic elevators, the subperiosteal dissection is carried out to create an optical cavity. Then, with the endoscope in place, the mandibular landmarks (posterior border, sigmoid notch, anterior border, condylar neck) and the fracture are identified.[17] The distal and proximal fragments are identified through the endoscope. A 24-gauge wire is passed through a 1.5-mm drill hole at the mandibular angle to allow the surgeon to distract the distal segment. A long-handled, narrow tipped clamp is used to grasp the condylar neck and to position the condylar head in the fossa. The fracture is reduced and the distracted mandible is released, wedging the 2 segments together. A 2.0-mm plate (Fig 4) is positioned with a special plate-introducer and the 2 proximal screws are placed. The introducer is then removed and the plate is used to manipulate the proximal fragment. Reduction of the posterior border is verified and the distal screws are placed. Screw placement is performed through the incision or with the aid of a percutaneous trocar.[17]

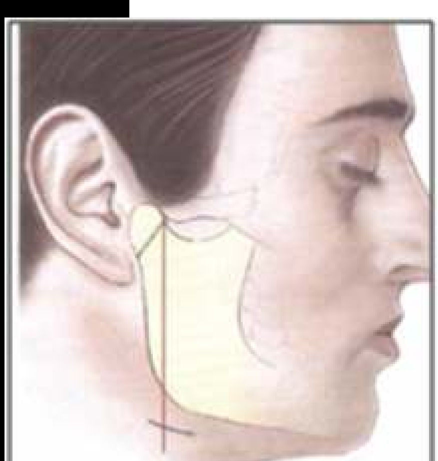

Fig 3: Orientation of endoscope through submandibular incision

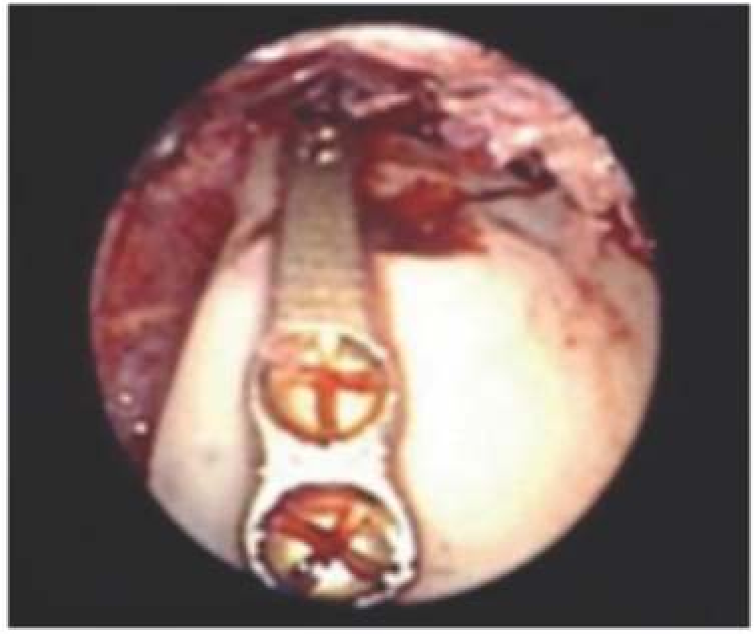

Fig4: Endoscope view after plate placement

Fractures of Orbital floor

The orbital floor blowout fracture is characterized by the involvement of only the wall of the orbit with an intact orbital rim after blunt trauma.[22]The term "blow out fracture" was coined in 1957 when Smith and Regan described inferior rectus entrapment with attendant decreased ocular motility in the setting of an orbital floor fracture.[23]It is classified as either amedial part of blow out fracture(Fig 5) or aLateral part of blow out fracture (Fig 6).[24]

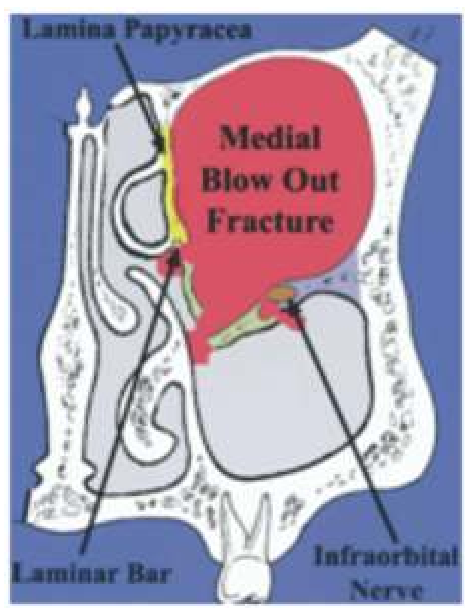

Fig5: Illustration of medial part of blow out fracture.The medial floor is comminuted and depressed into the maxillary sinus. The fracture extends medially to the laminar bar and laterally to the infraorbital nerve.

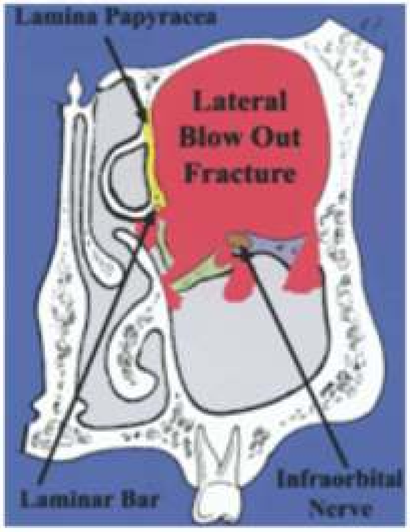

Fig6: Illustration of lateral part of blow out fracture. The entire orbital floor is comminuted and depressed into the maxillary sinus. The fracture extends medially to the laminar bar and laterally to the lateral orbital wall. The infraorbital canal is disrupted

An upper buccal sulcus incision is given. The maxillary face is exposed in a subperiosteal plane and the dissection is extended to the level of infraorbital nerve. An antrostomy is made in the thinnest area of the maxillary sinus wall. This can be performed with an osteotomes or with the oscillating saw. The antrostomy is enlarged. The final antrostomy (Fig 7) should be approximately 1 x 2 cm and placed 1 to 2 mm below infraorbital nerve lateral to the nasal aperture. Finally an endoscope notch is placed in the central portion of the antrostomy. This notch provides tactile feedback to the assistant surgeon, stabilizing the endoscope while keeping his / her eyes on the monitor. The bone can be plated back in place after completion of the procedure.

The sinus cavity is visualized using a 30 degree endoscope with an irrigation sheath, the orbital floor anatomy is visualized. A pulse test(Fig 8) is performed to assess the fracture size, pattern and degree of orbital prolapse.[25] The location and extent of fracture is determined. With the aid of sinus instruments the maxillary mucosa is stripped circumferentially around the fracture site. The fracture is repaired by reducing the prolapsed orbital fat with a malleable retractor and closing the trap door.[26]

The advantages of endoscopically managing orbital floor fractures are:

- Allows repair of orbital floor fractures without facial scars
- Allow for immediate fracture repair without the need to await resolution of edema.
- Risk of eyelid deformity is alleviated
- Visualization of the fracture is greatly improved.[27]

Although there are advantages to this procedure there have been reports of associated complications such as blindness, diplopia, and globemalposition.[26]

Fig 7: 2 x 1 cm antrostomy with notch in the inferior aspect to accommodate the endoscope

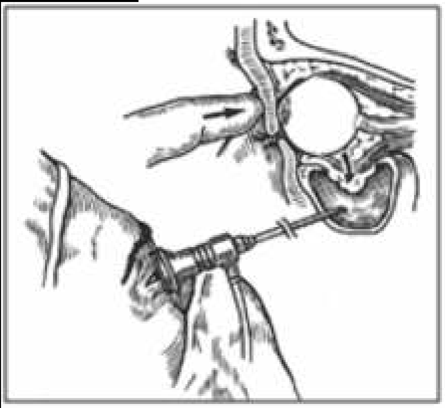

Fig 8: Illustration of pulse test. Mild pressure is applied to the globe and fracture is inspected from below with a 30 degree endoscope

Fractures of Frontal sinus

Frontal sinus fractures account for 5% to 15% of all maxillofacial injuries.[28] Endoscopic frontal sinus repair is indicated whenever repair of the anterior table fracture is important to restore the contour of the forehead but neither sinus obliteration nor cranialization are necessary.[8] There are two basic endoscopic treatment options: endoscopic reduction and miniplate fixation or camouflage of the contour defect.[1]

Suggested criteria for endoscopic reduction of frontal fractures.

1. Posteriorly displaced anterior table fractures
2. Wide anterior–posterior diameter of the frontal sinus and recess
3. Intact posterior frontal sinus table
4. Recent history of trauma.[29]

The basic technique involves two or three small incisions placed behind the hairline (Fig 9). A sub periosteal dissection exposes the depressed anterior table fragments (Fig 10). The most challenging aspect of this technique is the elevation of the depressed fragments. The most reliable method to elevate the depressed segments is to use a threaded fragment manipulator (Fig 11) basically a long self-drilling, self-tapping 2.0 screw that is inserted and screwed into the depressed fragment or fragments. A rocking and pulling motion is then used to reduce the fracture. Self-drilling screws (Fig 12) and screwdriver are introduced via small stab incisions; alternatively, a right angle screwdriver may be used.1

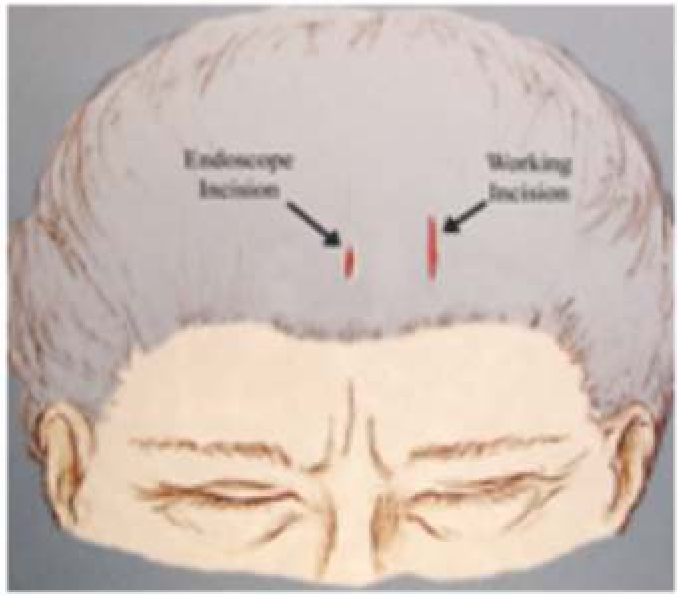

Fig9: Illustration of scalp incisions used for endoscopic repair of frontal sinus fracture

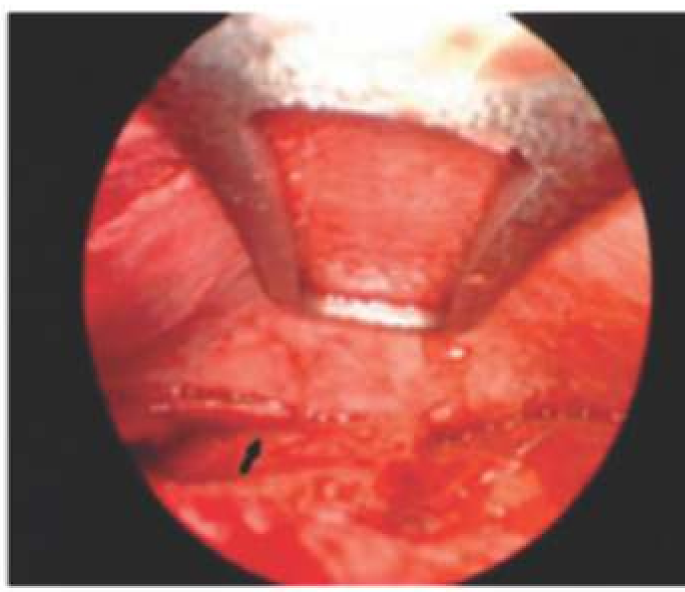

Fig10: Endoscopic view of depressed frontal sinus fracture

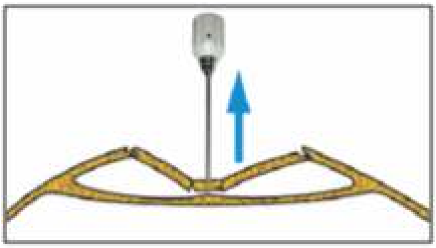

Fig 11: Threaded fragment manipulator is pulled outward

Fig 12: Miniplate fixation

The advantages of endoscopically managing frontal sinus fractures are:

- Reduces patient morbidity, operating time, and cost.[30]
- Small incisions hidden behind the hair line.[8]
- Magnified visualization of the fronto nasal duct allowing a more careful inspection of its patency.[8]

·The limitations of endoscopically managing frontal sinus fractures are:

- Severely comminuted fractures are not amenable to this technique due to the difficulty of reducing and holding multiple small fragments simultaneously.[1]
- Associated orbital roof blow-in fractures.[8]
- Fractures that extend over the orbital rim.[8]

Fracture of Zygomatic arch

The zygoma, because of its prominent position and contour is highly susceptible to injury. For zygomatic fractures, especially those involving displacement and telescoping of the zygomatic arch, a coronal approach is recommended for exposure and reduction of the zygomatic arch. The disadvantages of this approach are increased blood loss, risk of damage to the frontal branch of the facial nerve, possibility of bilateral temporal hollowing, permanent forehead and scalp numbness and a scalp scar which may result in alopecia, hypertrophic scarring and chronic scalp pruritus.[31]

The technique involves placement ofa small incision(Fig 13) located 2-3 cm behind the temporal hairline. The incision is deepened into the subgaleal plane and then a 30 degree telescope is inserted through the temporal incision to assist in the dissection. The dissection proceeds below the superficial temporal fascia using a periosteal elevator. After reaching the lateral orbital rim, subperiosteal dissection is carried out, inferiorly to exposethe zygomatic body and the anterior third of the zygomatic arch.

A posterior dissection proceeds below the superficialtemporal fascia inferiorly up to 1cm above the superior border of the posterior two thirds of the zygomatic arch. At this point, the dissection is deepened below the superficial layer of deep temporal fascia and downward to expose the fracture lines of the zygomatic arch under endoscopic visualization. This subperiosteal dissection is carried forward to connect with the previous anterior dissection, and the whole arch, upper part of the zygomatic body and entire lateral orbital rim are exposed. The inferior portion of the zygomatic body and infraorbital rim are exposed through an upper gingivobuccal incision under direct vision.

The displaced zygoma is disimpacted with an elevator through the oral incision and reduced to the anatomic position. Segmental fractures of the zygomatic arch are reduced using an endoscopic periosteal elevator via the temporal incisionwith direct endoscopic vision. The adequacy of reduction at the zygomatico frontalsuture is verified under the supervision of the endoscope. The miniplates were inserted through the temporal incision and screws (Fig 14) are inserted and tightened via a percutaneous trocar under endoscopic visualization.[31]

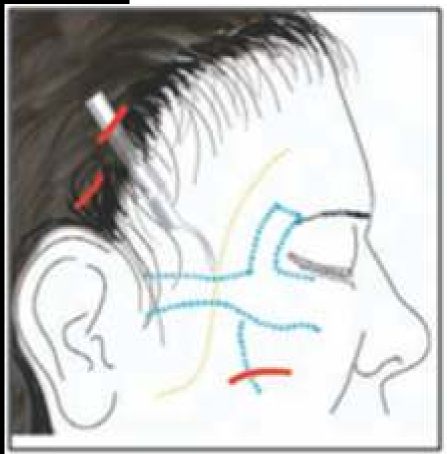

Fig 13: Schematic endoscopic approach to zygomatic arch with intraoral and hairline incision

Fig 14:Endoscopic drilling view for screw placement

The advantages of endoscopically managing zygomatic fractures are:

- Minimizationof scar.
- Less intraoperative hemorrhage
- Less numbness.
- Beneficial to thin haired and bald patients.[31]

The limitations of endoscopically managing zygomatic arch fractures are:

- Complicated fixation.
- Initial increased operating time.
- Wide learning curve.
- Risk of damage to frontal branch of facial nerve.[31]

CONCLUSION

Endoscope is revolutionizing the field of facial trauma management. The endoscope serves two principal roles in facial trauma management. It decreases morbidity of surgical access in the treatment of fractures where open reduction and internal fixation was considered standard. It also allows for anatomic reduction and stabilization of fractures.It is expected thatcontinued refinement in techniques, equipment and case selection will allow for better management of maxillofacial fractures.

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CELL FREE NUCLEIC ACIDS - A PROMISING MOLECULAR DIAGNOSTIC TOOL FOR CANCER

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ABSTRACT

Nucleic acids that are no longer confined within the cells but are dispersed in blood stream or in other body fluids are known as cell free nucleic acids(CNA).Minute amounts of CNA are constantly released from normal cells and tumor cells into the bloodstream. As a result of increased apoptotic and necrotic cell deaths during carcinogenesis, circulating cell-free nucleic acids are present in higher levels among the patients with cancer as compared to healthy individuals. Circulating cell-free nucleic acids in cancer patients often shows the same genetic and epigenetic alterations as DNA derived from related tumor tissue. The detection of CNA is a less invasive technique for molecular diagnosis and monitoring of cancer. It is also used in diagnosis of various other disorders like in autoimmune diseases, prenatal diagnosis of fetal genetic diseases, prion diseases and in monitoring of acute pathologies like stroke, myocardial infarction and trauma. This review focuses on the potential value of cell-free nucleic acids as a minimally invasive blood-based biomarker for cancer.

KEYWORDS

Circulating cell free nucleic acids, tumor, malignancy, genetic and epigenetic changes

INTRODUCTION

New discoveries in the biomedical field have remarkably enhanced our understanding of the pathology and etiology of disease, particularly originating from the genetic and molecular world. The use of DNA as a biomarker in clinical medicine for early diagnosis, prognosis and monitoring of therapy has been a significant advancement in the field.

Whether the DNA is present in normal locations such as the nucleus and mitochondria or circulating free in the blood and body fluids, it can be utilized as a valuable biomarker. Circulating cell free nucleic acids are thosenucleic acids that are no longer confined within the cells but are dispersed in blood stream or in other body fluids.In healthy subjects, CNAconcentrations arebetween 0 and 100 ng per ml of blood, with an average of 30 ng per ml.In cancer, levels of CNA increase and a range between 0 and >1,000 ng per ml of blood, with an average of 180 ng per ml blood, has been measured [1]. CNA in cancer patients often shows the same genetic and epigenetic alterations as DNA derived from related tumor tissue. Hence, use of DNA assays for clinical medicine can be significantly sensitive and specific if cancer-specific DNA alterations are tested instead of elevation of circulating DNA concentration.Thereforedetecting circulating DNA in cancer patients may help develop a DNA profile for early stage diagnosis in malignancies.[2]

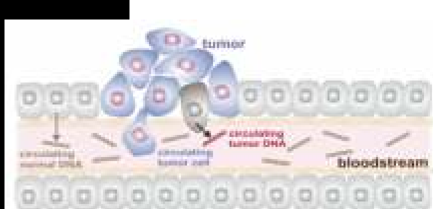


Fig 1: Schematic representation of a tumor releasing nucleic acids into the circulating blood stream.

HISTORY

In 1948, Mandel and Métaisin a French journaldescribed the presence of cell-free nucleic acid (cfNA) in human plasma for the first time. In 1977, Leon et al, reported high levels of CNA in patients with pancreatic cancer. Interestingly they even demonstrated that plasma CNA levels in patients actually decreased after chemotherapy.[3]In 1989,Stroun et al detected circulating DNA with neoplastic characteristics in plasma of cancer patients.[4]This attracted little attention in the scientific community and it was not until 1994 that the importance of cfNA was recognized as a result of the detection of mutated RAS gene fragments in the blood of cancer patients.[1]In 1996, microsatellite alterations on cell-free DNA (cfDNA) were shown in cancer patients. And during the past decade increasing attention has been paid to cfNAs (such as DNA, mRNA and microRNAs (miRNAs) that are present at high concentrations in the blood of cancer patients.[1] Besides cancer detection and monitoring, studies on circulating nucleic acids have opened up a new avenue for non-invasive prenatal diagnosis. This was made possible by successful detection of fetalderived Y-chromosomal sequences in maternal plasma and serum by Lo et al in 1997.In addition to these applications, CNA have been demonstrated to be potentially useful in monitoring trauma and stroke patients.[4]These genetic biomarkers can be an indication of neoplastic colorectal epithelial cells, and can thus potentially be used as non-invasive tests for the detection of the disease in CRC patients and monitor their staging, without the need to use heavier and invasive tools.They have also shown a promising sensitivity and specificity in the detection of malignant and premalignant neoplasms.[5]

SOURCES OF CNA

Although the evidences proving the presence of high levels of circulating DNA and RNA in plasma of cancer patients is increasing day by day, actual origin of CNA still remains enigmatic.[3]In healthy individuals, the concentration of circulating DNA is low, since most non-living cells are removed efficiently from circulation by phagocytes. Apoptosis is confirmed as one of the major sources of CNA in the plasma or serum. Additional minor source include cell lysis by the necrotic pathway, spontaneous release of newly synthesized nucleic acids by tumor cells.[2]

Necrotic and apoptotic cells are usually phagocytosed by macrophages or other scavenger cells.[6] Macrophages that engulf necrotic cells can release digested DNA into the tissue environment. In vitro cell culture experiments indicated that macrophages can be either activated or dying during the process of DNA release. Fragments of cellular nucleic acids can also be actively released. It has been estimated that for a patient with a tumour that weighs 100g, which corresponds to 3 × 1010 tumour cells, up to 3.3% of tumour DNA may enter the blood every day. On an average, the size of this DNA varies between small fragments of 70 to 200 base pairs and large fragments of approximately 21 kilobases.[7] Tumour cells that circulate in the blood, and micro- metastatic deposits that are present at distant sites, such as the bone marrow and liver, can also contribute to the release of CNA.[1]Molecular weight of circulating DNA may indicate its source. For example, apoptosis has been found to produce fragments of ~180 bp, whereas necrosis results in higher molecular weight fragments. When double stranded circulating DNA in plasma and serum is separated by gel electrophoresis, the fragments tend to form a ladder rather than a smear. The ladder fragments are mainly 180–1000 bp in size and so are likely to be formed by apoptosis. DNA released by necrosis is incompletely and non-specifically digested and thus smears on electrophoretic separation due to its fragment sizes of about 10,000 bp.[8,9,10]

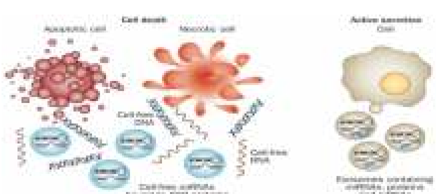


Fig 2: Mechanisms of release of cell free nucleic acids into systemic circulation – apoptosis, necrosis, and active cell secretion.

Tumors usually represent a mixture of different cancer cell clones (which account for the genomic and epi-genomic heterogeneity of tumors) and other normal cell types, such as haematopoietic and stromal cells. Thus, during tumor progression and turnover both tumor derived and normal CNA can be released into the blood. As such, the proportion of CNA that originates from tumor cells varies owing to the state and size of the tumor. The amount of CNA is also influenced by clearance, degradation and other physiological filtering events of the blood and lymphatic circulation.CNA is composed of both genomic DNA (gDNA) and mitochondrial DNA (mtDNA).Genomic DNA circulates mostly in a cell-free form and has also been isolated from micro vesicles (which include exosomes and apoptotic bodies) mitochondrial DNA circulates mainly in microvesicles.[10] Interestingly, the levels of cell-free mtDNA and gDNA do not correlate in some tumour types, indicating the different nature of circulating mtDNA and gDNA.[1]As diagnostic and prognostic marker in prostate cancer patients the amplification of mitochondrial nucleic acids has been reported to display increased sensitivity and specificity over genomic DNA.[10]

Theoretically, CNA would be rapidly degraded in the bloodstream by nucleases; it has even been proven that mutated CNA degrades faster than non-mutated CNA. However, the enzymatic action might be limited because at least part of CNA appears to be protected by being complexed or particulate with special protective characteristics against enzymatic degradation. A decreased activity of DNase has also been observed in plasma from cancer patients, which might be another reason for the high levels of CNA found in plasma.[11]In addition to plasma/serum, detectable levels of endogenous CNA can be quantified in other body fluids such as urine, synovial fluid, saliva and cerebrospinal fluid.[12]

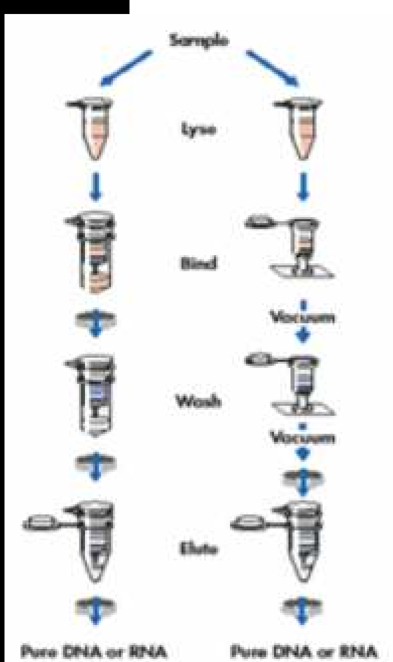
RETRIEVAL OF CNA FROM BLOOD

The quantity of circulating cell freenucleic acids in plasma, serum, and other body fluids is usually low and its isolation is still a challenge especially to determine the origin of the circulating nucleic acids.

Techniques used for CNA analysis are one of the major obstacles in translating CNA analysis to clinical practice. No standard operating procedure currently exists despite several on-going clinical studies on CNA analysis. Preanalytical parameters potentially affecting CNA concentration and fragmentation are present at every step from blood draw to the storage of DNA containing sample.The following methods may be used for obtaining circulating nucleic acids for clinical analysis.

A) QIAamp Method and Modified QAIamp Protocol

CNA is commonly isolated using commercial kits such as QIAmp 96 spin blood DNA extraction kit supplied by Qiagen.[3]TheQIAamp [redacted]esigned to purify genomic, [redacted]rial, and bacterial DNA, [redacted]r RNA, or viral nucleic acids [redacted] range of clinical samples [redacted]eam amplification and [redacted]plications. QIAamp Kits [redacted]ation of nucleic acids with [redacted]lumn or 96-well-plate [redacted]. No phenol-chloroform [redacted]s required. Nucleic acids [redacted]cally to the QIAamp silica-[redacted]ne while contaminants [redacted]h. PCR inhibitors such as [redacted]tions and proteins are [redacted] removed in two efficient [redacted] leaving pure nucleic acid [redacted]d in either water or a buffer [redacted]th the kit.[2]



[redacted]agen amplification spin [redacted]ocedure in microfuges on [redacted]acuum manifolds

[redacted]eat/Phenol Protocol [redacted]NA Purification

[redacted]d has good-quality [redacted]he blood samples should [redacted]or below room temperature (18–22 degrees C) for no more than 2 h before plasma separation by double-spin. Due to the higher efficiency, low-cost and good-quality products, this method is preferred in many circumstances for extraction of DNA. Furthermore, the modified phenol-chloroform (MPC) technique can extract more plasma cell free DNA than the Qiagen kit method.[2]

C) The NucleoSpin Method

This is a very rapid method, resulting in a high purity DNA yield. The NucleoSpin method may be used for the retrieval of small DNA fragments.[13]

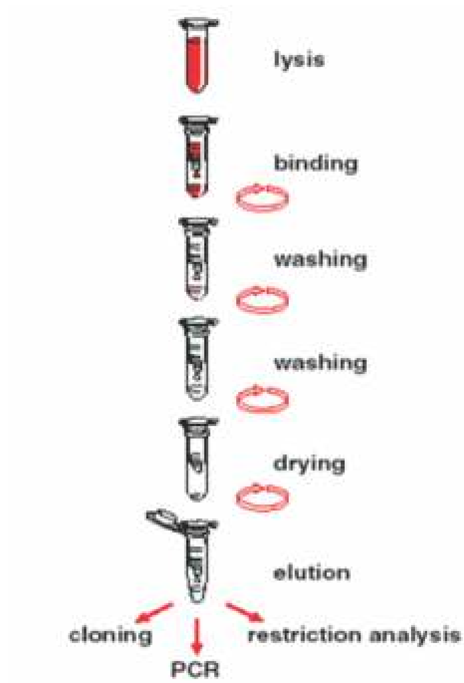


Fig 4:Nucleospin procedure

D) Blunt-End Ligation-Mediated Whole Genome Amplification (BL-WGA)

This is a single-tube reaction. Purified double-stranded DNA is blunted with T4 DNA polymerase, self-ligated or cross-ligated with T4 DNA ligase, and amplified via random primer-initiated multiple displacement amplification. BL-WGA improves sensitivity for detection of circulating tumor-specific biomarkers from bodily fluids or for recovery of nucleic acids from sub-optimally stored specimens.[2]

E) Quantitative polymerase chain reaction [PCR]

Polymerase chain reaction (PCR) is a new popular molecular biology technique for enzymatically replicating DNA without using a living organism, such as E. coli or yeast. The technique allows a small amount of the DNA molecule to be amplified many times, in an exponential manner.The technique PCR was developed in 1983 by Kary Mullis.With introduction of PCR, picogram quantities of DNA can be detected.Quantitative real time PCR further increased sensitivity to 90%. However, effective anti-contamination measures should be strictly imposed since the sensitivity.[4,14]

Other methods include, the more sensitive RNA-DNA hybridization, RIA, and counter-immunoelectrophoresis assays, nanogram amounts of circulating DNA can be quantified.With real-time PCR and PicoGreen double-stranded DNA quantification assays,it is now possible to quantify picogram amounts of circulating DNA.[9,15,16]

GENETIC AND EPIGENETIC CHANGES IN CNA

Cancer development involves an accumulation of genetic and epigenetic changes such as point mutations, chromosomal rearrangements, microsatellite instability and promoter hypermethylation.[4]Epigenetic alterations can have a substantial effect on tumorigenesis and progression. Several studies have revealed the presence of methylated DNA in the serum or plasma of patients with various types of malignancy. The detection of methylated cfDNA represents one of the most promising approaches for risk assessment in cancer patients.[1]Assays for the detection of promoter hypermethylation may have a higher sensitivity than microsatellite analyses, and can have advantages over mutation analyses. In general, aberrant DNA methylation, which seems to be common in cancer, occurs at specific CpGdinucleotides. The acquired hypermethylation of a specific gene can be detected by sodium bisulphite treatment of DNA, which converts unmethylated (but not methylated) cytosines to uracil. The modified DNA is analysed using either methylation-specific PCR, with primers that are specific for methylated and unmethylated DNA, or DNA sequencing. Nevertheless, to improve the assay conditions and the clinical relevance, the selection of appropriate tumorrelated genes from a long list of candidate genes that are known to be methylated in neoplasia is essential. Although epigenetic alterations are not unique for a single tumor entity, there are particular tumor suppressor genes that are frequently methylated and down regulated in certain tumors. For example, important epigenetic events in carcinogenesis include the hypermethylation of the promoter region of the genes pi-class glutathione S-transferase P1 (GSTP1) and APC, which are the most common somatic genome abnormalities in prostate and colorectal cancer, respectively.

MicroRNAs (miRNA) are a group of gene-specific regulators and can be detected as cell free circulating RNA. miRNAs are f20-nt long, single-stranded, noncoding RNA molecules. They are encoded in long primary forms in the nucleus. miRNAs could control the expression levels of particular genes. Thus, dysregulation of miRNAs is expected to be found in diseases, such as cancers, which are attributed to dysregulated gene expression.

It was suggested that miRNA alteration could initiate carcinogenesis.Plasma miR-184 levels were significantly higher in patients with tongue SCC in comparison with the normal individuals. This suggests that the increased miR-184 in SCC patients may be related to the presence of primary tumor.MiR-184 is a candidate oncogenic miRNA in tongue SCC and might play a part in the antiapoptosis and proliferation of tongue SCC cells.[16]

Loss of Heterozygosity (LOH) analysis of alleles at specific chromosomes of cell free plasma or serum DNA can add remarkable diagnostic and prognostic value for early evaluation of primary tumors such as mucosal melanoma, gastrointestinal stromal tumors, prostate carcinomas, and others. Studies have shown that LOH can indicate tumor recurrence and can correlate with tumor status.From the methodological point of view it is very important to mention that circulating DNA is present in high and low molecular weight fractions, especially for breast and ovarian cancer.

It has been demonstrated that LOH at different loci are found in the low molecular weight fraction. Thus, fractionation of circulating DNA is essential for achieving reliable results.[1]

Microsatellites are repeated sequences of DNA in which a short motif (usually 1–6 base pairs in length) is repeated 5–100 times. Expansions of microsatellite DNA repeats contribute to the inheritance of nearly 30 developmental and neurological disorders. Frequently, these disorders involve nearly all DNA transactions including replication, repair, recombination, and transcription. MSI is the genomic evidence that results from malfunctioning of the Mismatch Repair System (MMR). DNA MMR corrects errors that spontaneously occur during DNA replication. Single base mismatches or short insertions and deletions are identified then subsequently excised and repaired. Cells with abnormally functioning MMR tend to accumulate errors rather than correcting those errors. MSI can be detected in cell-free DNA and may increase the detection of cancer diagnosis and progression. MSI is associated with several cancer subtypes and testing for MSI-CNA depends on a small number of known microsatellite loci or mismatch repair genes which represent some challenge to use this application.[17]

In 90% of squamous cell carcinomas of the oral cavity, there is a microsatellite alteration in serum DNA that is identical to those in the corresponding tumor DNA. This may provide valuable prognostic information and serve as a guide for future therapy. There are nine microsatellite loci of LOH that have been identified on chromosomes 2, 3, and 21 related to the SCC of oral cavity.[1]

OTHER DIAGNOSTIC IMPLICATIONS OF CNA

Autoimmune diseases: Increasedlevels of cell free DNA in auto-immune diseases like rheumatoid arthritis, systemic lupus erythematosus, systemic sclerosis and primary Sjögren's syndrome have been studied by various authors.[18]

Inflammatory conditions: Increased CNA levels are not only specific for neoplasms, theycan also be found in various inflammatory conditions such as liver cirrhosis and hepatitis.[19]

Transplantation: Microchimerism is the presence of a small quantity of foreign cells or foreign DNA in either a tissue or circulation of a person. Naturally acquired micro- chimerism occurs in two-way transplancental traffic between the mother and fetus while iatrogenic microchimerism occurs as a consequence of a transfusion or transplantation. Quantitative analysis of a total and transplant specific DNA (Tr-DNA) in urine and/or in plasma of the recipient has shown as a good complementary marker of a transplant acceptance or rejection and it can be helpful in the optimizing of immunosuppressive therapy and selective application of a kidney biopsy following a renal transplant.[20]

Trauma and sepsis: Following a severe trauma, systemic anti-inflammatory response appears which can lead to the organ failure and that after the increased cell death result is the increase of free DNA level in circulation. Lo et al. have presumed that in patients with a blunt trauma andburns the level of free DNA will be changed. They have determined that free DNA in those patients is increased depending on the severity of injury and can serve as a prognostic marker for the complication development and the recovery length.[21]

Acute myocardial infarction: Elevated levels of the cell-free DNA in circulation is connected to the cell death whether as a result of a tissue injury or as a result of an inflammatory reaction. Since the acute myocardial infarction is characterized by a combination of necrosis and apoptosis of the myocytes,elevated levels of CNA can be noted.[22]

Acute stroke: In the case of acute stroke,specific markers do not exist in clinical practice. Considering that pathophysiology of a stroke includes both cell death and blood- brain barrier dysfunction, a group of researchers from Hongkong, decided to explore the level of free DNA in plasma of patients with acute stroke. Samples have been collected in a period of 24 hours from the symptom occurrence and results have shown that plasma DNA concentration correlates with the strokes severity and that it can serve as a mortality and morbidity predictor even in those patients with no visible changes detected by neuroimaging techniques.[23]

Acute mesenteric ischemia:A group from Spain investigated free plasma DNA levels in order to diagnose patients with acute mesenteric ischemia since diagnosing this in emergency ward is challenging and quite often results with mortality. They found that plasma DNA levels may be a useful biomarker in predicting the outcome of patients with acute mesenteric ischemia.[24]

Non-invasive prenatal diagnosis:Cell-free fetal nucleic acids can be detected in the maternal circulation during pregnancy, potentially offering an excellent method for early non-invasive prenatal diagnosis of the genetic status of a fetus.They can be detected from 5 weeks gestation and are rapidly cleared from the circulation following birth. Currently, since the cell free fetal nucleic acids comprises only 3–6% of the total CNA, diagnoses are primarily limited to paternally inherited sequences as well as conditions that can be inferred by the unique expression of fetal RNA by the placenta. The main advantages of using cell free fetal nucleic acids over conventional techniques of prenatal diagnosis (amniocentesis)are that the sampling method is non-invasive and therefore poses no risk to mother or child, and it can be performed early during the first trimester and would most likely be cheaper. Broadly, the potential applications fall into two categories of prenatal testing:high genetic risk families, routine antenatal care in all pregnancies, including aneuploidy screening, particularly trisomy 21, and diagnosis of Rhesus factor status in RhD negative women.[25]

CONCLUSION

Carcinogenesis and tumour progression are complex and progressive processes that are associated with numerous genetic and epigenetic alterations.Histological evaluation of tumour tissues obtained from biopsies, as well as blood samples, are the 'gold standard' of diagnosis, but most studies usually carry out these evaluations once only. We now know that metastatic and primary tumours from the same patient can vary at the genomic, epigenomic and transcriptomic levels, thus assays that allow the repetitive monitoring of these events using blood samples would be more efficient in assessing cancer progression in patients from whom tumour tissue is not available.Therefore detection and analysis of CNA as a non-invasive, rapid, sensitive, reliable & reproducible tool for molecular diagnosis & monitoring of cancer can be of valuable importance.The overarching goal of utilizing CNA as biomarkers is, to optimize medical practice, advance personalized medicine, and improve the quality of life.

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DIGITAL MODELS – VIRTUAL REALITY

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ABSTRACT

Digital technology has changed orthodontic laboratory operations immensely over the last 15 years. The process has been slower in orthodontics than in other fields because of the relatively small market size of the orthodontic laboratory, with most transitions pioneered by the dental laboratories. The use of stone and plaster study models is an integral part of any dental practice and is required for research. Storage of study models is problematic in terms of space and cost. Impression-free techniques might eliminate the potential shortcomings of digital dental models. Chair side scanners offer the advantage of obtaining digital dental models directly from the patient without the need for dental impressions.In the era of the 'electronicpatient record', when all patients information will bestored digitally, commercially available digital model systems, will become the norm

KEY WORDS

Digital Models, Intraoral Scanners, CBCT, virtual set up, 3-Dimension

INTRODUCTION

The use of stone and plaster study models is an integral part of any dental practice and is required for research. Storage of study models is problematic in terms of space and cost. Ayoubet al. introduced a new technique based on the recent advances in stereo photogrammetry for archiving dental study models in a digital format. [1]

Four relatively new technologies are now keys in orthodontic specialty laboratories: digital photography, Laser welding, Computer-aided design/computer-aided manufacturing (CAD/CAM), and Intraoral scanners.Successful treatment planning in dentistry requires precise diagnostic information and an extensive diagnosis.[2]

In orthodontics, dental model analysis is an essential part in the process of diagnosis. Dental models can be used to evaluate occlusion and perform measurements more easily and accurately than in the patient's mouth.[2]

In the early 1990s, CAD/CAM techniques began impacting dentistry. (Fig 1)Systems became available to create restorations digitally, making for many positive changes in laboratory operations.[2]

Fig 1: CAD/CAM Technique

The first products to impact the orthodontic market were digital study models and aligners.[1]Companies began promoting digital dental casts as a viable alternative to the plaster study model service provided by laboratories. The plaster study model service was time-consuming, took up much needed space in the laboratory, and created storage issues for orthodontists. [2]

Digital study models solve these problems. The models or impressions can be scanned, and the plaster models discarded. The next generation of model and impression scanning is currently underway. At least 6 intraoral scanners (Fig 2) are on the market or are slated for release soon.This scanning process, which eliminates the need for impressions, can take 5 to 15 minutes, depending on the operator. Intraoral scanning will give the doctor a competitive advantage: data can be sent immediately to the orthodontic laboratory, where technicians "print" a model to construct an appliance.[2]

Fig 2: Intra oral scanner

The benefits of intraoral scanning include: reduced shipping costs, elimination of biohazard issues in the laboratory, reduced time for product manufacturing, and task reduction for staff on a daily basis. The 3-dimensional view allows the laboratory to better accommodate orthodontists' needs for their patients. The technology is innovative and exciting, but costprohibitive to most orthodontic laboratories. As with any new technology, scanners will become more affordable after some time on the market.[3]

Shortly after the American Association of Orthodontists' meeting in 2008, the 3-Shape 3-D scanner became available to orthodontic laboratories at a reasonable cost. This scanner allows the capture and manipulation of the data in many ways: the models or impressions can be scanned; band or crown sizes can be determined, interproximal reduction can be reviewed if needed, a Bolton analysis can be accomplished, and any model that has been duplicated can be inspected within microns of measurement for accuracy.[4]

Rapid prototyping is a fast-developing technique that might play a significant role in the eventual replacement of plaster dental models. Dental models reconstructed by the tested rapid prototyping techniques are considered clinically acceptable in terms of accuracy and reproducibility and might be appropriate for selected applications in orthodontics. The advantage of this method compared with the conventional method (plaster models) is substantial; it has benefits in efficiency, ease of use, longevity (no risk of physical damage), and storage space (a hard disk instead of physical space).The applications of rapid prototyping in orthodontic practices are increasing.[5,6]

For orthodontics, the most important expectation from a digital model system lies in its diagnostic accuracy and reliability. However, there is also contrary evidence in the literature that supports the validity of digital models for the aforementioned measurements.[7]Many professionals obtain their digital models through the use of proprietary services. Traditional impressions and plaster models must be submitted to the selected company so that they can be scanned and the digital models can be generated and made available for downloading.[8] Submission of models or impressions by mail can result in breakage of the models or distortion of the impressions during shipment. Even if no breakage or distortion occurs during shipment, the impression materials have an inherent amount of distortion at their time of use.[9]

Perhaps elimination of the conventional impression step and generation of dental models directly from the 3-dimensional (3D) dental anatomy will yield more accuracy. One way of doing this is to use the DICOM files produced by cone-beam computed tomography (CBCT) scanners. An advantage of this technology is that it allows for the visualization of supragingival structures as well as impacted teeth, bone levels, and joints.[10]. Studies using various scanners have been published showing that diagnostically accurate measurements can be made from CBCT scans[8,11]. Perhaps the greatest drawback of using these scanners to acquire digital models is the required radiation exposure to the patient and the equipment expense to the practitioner. The radiation dosage is considerably lower with cone-beam computed tomography than in conventional computed tomography scanning.[12] Cone-beam computed tomography also has other advantages, including shorter acquisition times and reduced costs. Although the precision of the tooth crown on cone-beam computed homographs is low, this disadvantage would be offset by integrating the tooth crown of the dental cast with that of the cone-beam computed tomographs. The scattered radiation of cone-beam computed tomography is greater than conventional computed tomography because of the plane detector of the cone beam computed tomography.[13]

To overcome these disadvantages, 3-dimensional digital dental models are an alternative. Additional advantages of digital models are easy storage and exchange with electronic data transfer.

Digital models can be virtually manipulated, precise cross-sectional views can be created, and they can be magnified. Commercially available digital models can be produced by a direct or an indirect method. Indirect methods begin with dental impressions. Digital models can then be obtained by laser scanning of plaster models or computed tomography imaging of the impressions or plaster models. The direct method uses an intraoral scanner to scan directly in the patient's mouth, making dental impressions redundant.[14]. This can be advantageous for patients with a gag reflex or with cleft lip and palate, who are at risk of aspiration and respiratory distress during taking of the denta limpressions.[13]

Recently, the validity of digital models produced with an indirect method was evaluated in a systematic review by assessing the agreement of measurements on digital and plaster models. It was concluded that digital models offer a high degree of validity, and measurement differences are likely to be clinically acceptable.[15](Fig 3)

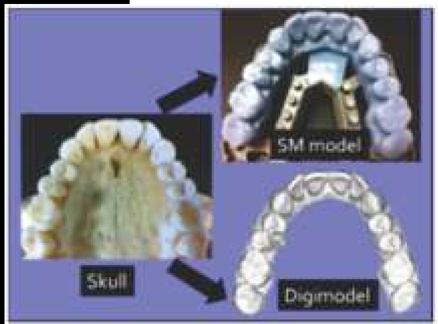


Fig 3: Examples of a skull model, a stereolithographic (SM) model, and a digital model(DM)

The features of our laser beam scanning system are as follows:[5]

1. High-speed measuring and processing. Unlike the spot laser measuring method, this system produces 254-point data with a single slit scanning ray, thus greatly reducing processing time.
2. High accuracy. Usually, the resolution of the slit-ray projection is dependent on the pixel alignment of the CCD camera. To enhance the resolution, a one-dimensional camera with a large pixel count may be used, but this is time consuming because it involves spot measurement.

SPECIFICATIONS FOR DIGITAL MODELS IN UNIVERSAL FILE FORMAT

In order to provide access to board certification for all orthodontists who have moved to digital formats for orthodontic models, it is necessary that the ABO provide a pathway for accepting measurable digital formats in a non-proprietary manner. Therefore, the American Board of Orthodontics announces the acceptance of universal digital formats for pretreatment and interim models.[16]

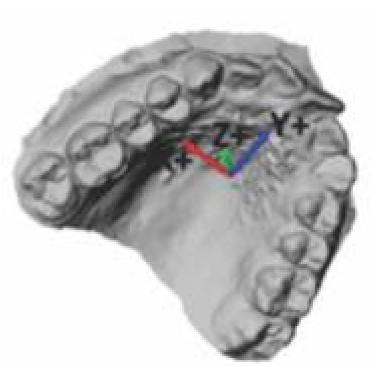
1. Digital model files must be one of three universal file formats: PLY, STL, or OBJ.
2. The mesh topology must be manifold. That is, each vertex is shared by a fan of triangles that forms a full disk or a half disk.
3. The mesh topology must be watertight. That is, there must not be any holes in the model. Where digital models do not have bases, a maximum of one hole (which corresponds to the boundary of the surface) is allowed in the mesh topology.
4. Pretreatment or interim digital model must be contained in one file or two files that include the maxillary arch and the mandibular arch. All triangles in each arch must be connected to each other.
5. The mesh must have a genus value of 0, except for larger handles/tunnels in cases where the impression actually had these handles/tunnels.
6. The two arches must show the patient's centric occlusal relationship demonstrating maximum intercuspation when viewed together.
7. A minimum of 12mm of soft tissue infra (mandible) and supra (maxilla) dentally should be present. This includes models that do not have digital bases. The palatal rugae must be included within the maxillary model.
8. Scan resolution must be at 0.10 millimeters or better. Scan accuracy must be at 0.20 millimeters or better.
9. All coordinates internal to digital model files must be in millimeters. This can be verified when viewing the model proportions under the 1 mm mesh of the Utility Viewer.
10. Digital bases must not be included in digital models submitted for examination. Digital models must be oriented according to ABO Operational Definition for Model Orientation.

ABO OPERATIONAL DEFINITION FOR DIGITAL MODEL ORIENTATION

A. The digital model orientation described here does not represent the relationship of the occlusal plane to the craniofacial anatomy, but only a spatial orientation allowing for repeatable measurements.

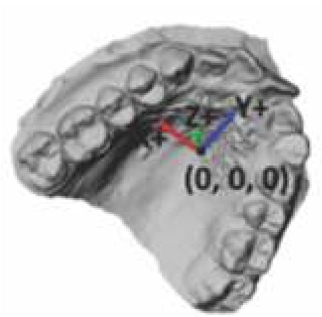
B. The digital model orientation is defined relative to the world coordinate system. Orientation of the model set is achieved relative to the maxilla.

1. Anterior orientation of maxillary model (Fig 4)



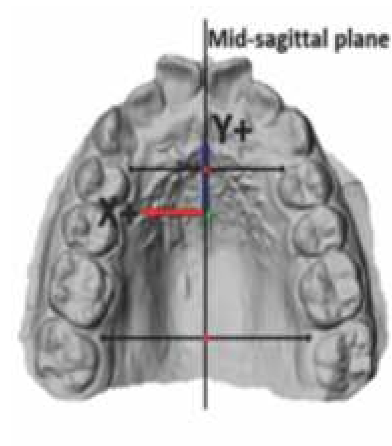
When the patient is standing, Z+ is up, X+ is toward the patient's right and Y+ is toward the anterior.

2. World orientation of maxillary model (Fig 5)



The world origin (0,0,0) is located on the mid-sagittal (Y-Z) and occlusal (X-Y) planes at a point that lies approximately half-way between the most anterior and most posterior teeth.

3. Occlusal orientation of maxillary model (Fig 6)



A plane containing the mid-palatal raphe will be considered the mid-sagittal plane and will coincide with the world Y-Z plane.

4. Leveling the maxillary occlusal plane (Fig 7, 8, 9)

The anterior and right maxillary images include a horizontal reference line that is used to level the model set such that the maxillary occlusal plane coincides with the world X-Y plane.

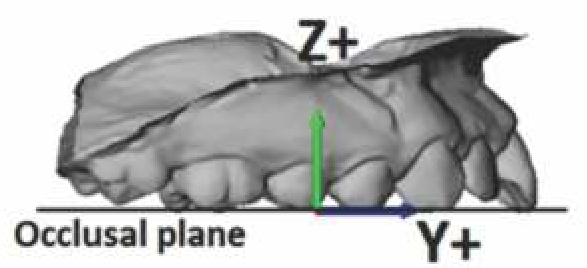


Fig 7: Leveling maxillary occlusalplane to world X-Y plane

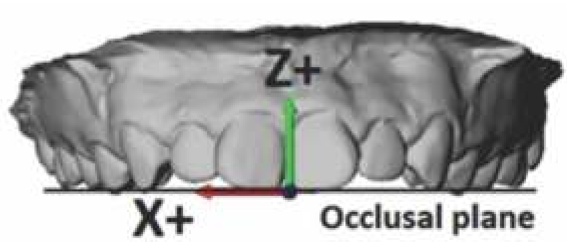


Fig 8: Leveling maxillary occlusal plane to world X-Y plane

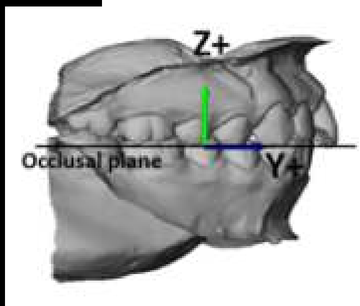


Fig 9: Leveling maxillary occlusal plane to world X-Y plane

The occlusal (horizontal) plane will coincide with the world X-Y plane. Theocclusal plane will be calculated based on an optimization, that is, the closest distance of the landmarks to a plane (Fig: 10). This discrimination will be included in the software algorithm.

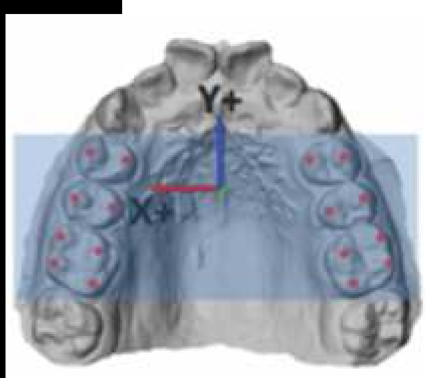


Fig 10: Calculation of occlusal plane

OTHER SERVICES OFFERED BY DIGITAL MODELS 17

The expanded technology also offers additional services:

Virtual set-up

This is a prediction system based on the straight–wire philosophy. It assumes wires are attached to the teeth and virtual tooth movements can then be undertaken. It allows the clinician to simulate the effect of extractions, different arch wires and different bracket prescriptions and positions. The accuracy of this system is yet to be fully tested.

Indirect bonding

The clinician sends the impressions and bite registration as usual, along with prescriptions and appliances. Once a treatment plan and bracket positions are approved on screen, software can fabricate indirect bonding trays.

Bracket placement

The principle behind this technique is that the clinician plans the position of each bracket on each tooth on the digital model. Additional hardware is then needed at the chairside to ensure the person placing the bracket has positioned it exactly in the prescribed position. This involves using a bracket placement device that is connected to the computer. This device includes a miniature video camera that transmits real time images from the patient's mouth to the screen. When the program detects an exact match between the projected image from the patient's mouth and the clinician-prescribed position on screen, an audio-visual sign is provided to let the clinician know that the bracket is accurately positioned and can be bonded.

CONCLUSION

Impression-free techniques might eliminate the potential shortcomings of digital dental models. Chairside scanners offer the advantage of obtaining digital dental models directly from the patient without the need for dental impressions. Direct digital acquisition of the dental arches with a chairside scanner provided almost 1-to-1 diagnostic information of the investigated anatomy and was superior to the cone-beam computed tomography measurements.

The multitasking abilities of the scanner fit well into the orthodontic laboratory's daily production and make a positive impact on the quality of the products. The technology allows for printing a physical model from a digital model, impression, or intraoral scan. A scanner is an excellent tool for expanding opportunities and allowing creative thinking.

Digital models are utilized, stored, viewed and managed. The ability to rotate, tilt and section models, and hold them in any position, potentially allows for far more detailed analysis, with the added advantage of bringing the models up instantly, along with the other clinical information, chair side. In the era of the 'electronic patient record', when all patients information will be stored digitally, commercially available digital model systems, will become the norm.Currently, there are no guidelines for the type of study models that are preferable, and it may be necessary to develop guidelines backed by sound scientific evidence to guide schools in decisions regarding the type of study models to be used in postgraduate residency programs.

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LINGUAL ORTHODONTICS: A REVIEW

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ABSTRACT

Orthodontic therapy is no more seen as a treatment for children or growing age group, but, today, more than ever, adult patients are becoming aware of protruding teeth, overcrowding and diastema, causing psychological problems connected with laughing or smiling. The aesthetic aspect has great importance in today's world. A pleasant aesthetic look increases people's self-confidence reinforcing a feeling of personal worth and provides reassurance when making personal contacts. Today, it is the most frequent motivating factor for encouraging patients to undergo orthodontic treatment, but due to social and work reasons patients probably refuse traditional orthodontic treatment. As a result, the orthodontic community has tried to improve the aesthetic aspect of the apparatus by introducing miniaturized brackets, in plastic or porcelain, but the results cannot be considered aesthetically satisfactory.

Invisible (Lingual) Orthodontics represents the only solution to the desires for the utmost in Aesthetics as well as Functional Excellence without the risk of damaging biomechanical efficiency. It plays an important role in achieving the dental alignment, a smile revealing aesthetic harmony, at an age as difficult as that of adolescent.

KEY WORDS

lingual brackets, invisible orthodontics, aesthetics

INTRODUCTION

The development of numerous orthodontic techniques together with notable progress from a commercial technological point of view has led to the achievement of exceptionally high orthodontic standards. In fact, there are no limits to the solution of any kind of malocclusion, whether dental, skeletal, with high percentage of success. Various sources of information have increased public interest in forms of treatment and recent advance and discoveries have strengthened the concept of treatment which can improve the well-being of a person not only in a limited area but in the body as a whole. Moreover, demographic and cultural changes during the past few years have contributed to a new chapter of Orthodontics.[1]

Since its introduction, lingual orthodontics has had varying fortunes which have sometimes prejudiced its prospective global diffusion. The last three decades have seen a marked increase in the number of people desiring Orthodontic Treatment, especially adults and everybody is striving for the utmost in Aesthetics as well as Functional Excellence.

Though the Lingual Appliance should not be approached with unrealistic expectations by the Orthodontist & the Patient but, with the brackets, arch wires and the techniques that have been developed, it is now possible to match the standards achieved with labial techniques. The Lingual Technique combined with the labial technique and the advances in computer-generated technology are changing many aspects of Lingual Orthodontics and present an exciting challenge for the future. And these Concepts of Lingual Orthodontics are drastically changing the whole scenario of the Orthodontic Community.

HISTORY

"Evolution Occurs on Demand" was the front liner, which led to the concept of Lingual Orthodontics. The increased demand for adult brought unique concerns to the profession. The adult population cited Metal Mouth Appearance of Conventional Labial Appliances as one of the primary reasons for not undergoing orthodontic treatment & esthetic concerns continued to be primary obstacle in treating adult populations with labial appliances. While esthetic became the major concern, alternatives to traditional orthodontic treatment were growing among the dental professionals.[2]

Clear plastic brackets were introduced as an alternative, but were fraught with inconveniences like, Staining of the bracket and distortion of the slot during torque expression. Since plastic and other labially bonded brackets have not provided the esthetics many orthodontists considered bonding brackets, on the lingual tooth surface and attempted lingual orthodontics.

The possibility of using appliances on the lingual surfaces of teeth was first suggested by Pierre Fauchard in 1726. In 1841, Pierre Joachim Lefoulon designed the first lingual arch for expansion and alignment of the teeth. [3]

Lingual Orthodontics as we understand today (a full multibracket appliance), began in the 1970s. The lingual appliance was not the consequence of esthetic demand, but it was started in Japan by Dr. Kinya Fujita of Kanagawa Dental University, to satisfy the orthodontic needs of the patients who practices martial arts, to protect the soft tissues (lips & cheeks) from possible impact against brackets. Fujita was the first to develop the lingual multibracket technique using the mushroom-shaped archwire.[3] He submitted his concepts on lingual orthodontics in 1967, began his research in 1971 and published the Fujita method in 1978 & December 1979, describing the appliance with a lingual bracket design and mushroom shaped arch wires. This appliance was developed to make use of the orthodontic forces coming from the lingual and palatal surfaces of the teeth to move the teeth tri-dimensionally for the correction of malocclusions. The Fujita bracket had three slots – occlusal, horizontal and vertical.

During early 1970's, Dr. Craven Kurz, Professor of Occlusion & Gnathology at the UCLA School of Dentistry, California found his practice dominated by celebrities and public figures, who refused orthodontic treatment with Labial Appliances, on esthetic grounds. Dr. Kurz with the help of a colleague Dr. Jim Mulick, developed the concept of Lingual Bonding Appliance and modified the labial appliance to give the first true Lingual Appliance, for an employee of "Play Boy Bunny Club".[4]

In early 1970, ORMCO, a company in California, in conjunction with Dr. Jim Wildman attempted to develop a system consisting of a pedicle positioned rather than a multibracketed system, to align the dentition using lingual approach. But due to various reasons this system did not gain popularity. During these early stages, ORMCO created a product development team to work with Dr. Kurz and his new appliance. In 1976, a turning point occurred in the development of the appliance when Dr. Kurz submitted aspecific design. It was the addition of an Anterior Inclined Plane as an integral part of the Maxillary Anterior Brackets. This inclined plane converted the Shearing Forces produced by the mandibular incisors to Compressive Forces applied in an intrusive and labial direction. These forces also produced a natural physiological bone resorption in the maxillary and mandibular incisor area allowing the teeth to intrude gently while swallowing.[4]

In 1978 detailed studies were conducted, measuring the morphology of the lingual surfaces of the teeth in order to reduce the size of the bracket bases and facilitate lingual bonding. The lingual arch form was studied topographically, to establish lingual torque and tip angulations in reference to accepted labial measurements. From this accumulated data and using a design concept to assure proper function and patient comfort, the initial lingual edgewise prototype (a usable metal bracket) was manufactured by ORMCO in 1979. From the initial clinical testing, which was done by Dr. Kurz on 100 cases, the appliance appeared to be viable and showed much promise in providing the profession with an aesthetic alternative to labial appliance.[4]

To establish beta test sites, a task was developed from fifty selected orthodontists who started presenting various seminars on lingual appliance by early fall of 1981.By this time “News Media” hyped the development of “Invisible Braces” in international magazines and television. The interest of public was heightened and the demand of the appliance forced urgency on the research and development team to provide the appliance for wide scale use as quickly as possible. Commercial companies were competing to be at the forefront of this “Lingual Fever” and marked this as “A Golden Era of Lingual Orthodontics”. The technique and appliance were still in their infancies and the beta testing had not yet been completed.

The 1987 saw the decline of the Lingual Orthodontics. There seemed to be widespread problems with appliance placement through direct bonding technique and manipulation of arch wire on open buccal segments with no occlusion because of the bite plane effect of the anterior inclined plane. Many clinicians experienced a loss of control in cases treated with lingual approach. And the introduction of “Starfire Brackets” – a truly clear, stain resistant labial bracket, gave a major setback to the lingual orthodontic therapy.[4]

Enthusiasm for lingual therapy waned in the profession, and commercial interest also declined. The original Ormco Task Force was reduced to just three members by 1988, Dr.Kurz, Gorman, and Smith. They restructured the group and were renamed KGS Ormco Task Force Number Two. Various innovations were done in the bracket design by Dr. Kurz and Kurz lingual bracket developed and evolved till 7th Generation ORMCO Lingual bracket in 1990. Kurz also developed various pliers and instruments for the clinical practice of lingual orthodontics; he was the owner of 22 patents.

In 1989, Creekmore developed a complete technique with vertical slot lingual brackets, together with a laboratory system (The Slot Machine). He also designed arch wire templates and clinical instruments. The biomechanics of his lingual brackets (Conceal; 3M Unitek) was based on his previous uni-twin labial bracket, which increased the interbracket distance but maintained rotation control with extended wings.[5]

Various new professional associations like The American Lingual Orthodontic Association (ALOA), European Society of Orthodontics (ESLO), AssociazioneItalianaOrtodonziaLinguale (AIOL) or the

Italian Society of Lingual Orthodontics were being formed during this period, which remained active in their support of lingual therapy. Asian Lingual Association and the French Lingual Orthodontic Society were also developed during this period.[6]

In 1996, Craven Kurz, William Laughlin, Thomas Creekmore, Jim Wildman together with other orthodontists founded the Lingual Study Group, in Denver, Colorado, with the aim of relaunching Lingual Orthodontics, especially in United States. And in 1997, American Lingual Orthodontic Association (ALOA) was reactivated and since then has prospered and continues to attract to their annual meetings, increasing numbers of clinicians from around the world.[6]

Newer brackets and arch wire designs and advanced techniques have been proposed by various authors explicating the lingual therapy.

Second generation Self Ligating Brackets, Evolution LT, were introduced in 2001, in Germany by HattoLoidl. In 2002, Aldo Macchi& Giuseppe Nidoli developed a self-ligating bracket with vertical slots for anteriors and horizontal slots for posterior teeth.

In 2003, Giuseppe Scuzzo& Kyoto Takemoto from Japan developed a prototype of lingual straight wire bracket and technique, the Stb (Scuzzo/ Takemoto bracket, ORMCO), facilitating the use of light forces with reduced friction and small bracket size enhancing patient comfort.[7] In the same year, in Germany, Dirk Weichmann introduced the incognito bracket which perfectly adapts to the lingual surface of the teeth, using a scanned model, the bracket base and bracket itself is cast as one unit for each individual tooth. The prescription of tip & torque is customized according to the orthodontist's treatment plan.[8]Again in year 2003, individual indirect bonding technique (IIBT), the mushroom bracket positioner, as well as the Lingual Straight Wire Technique was introduced by Hee-Moon Kyung.[9]

In 2004, Tae Weon Kim of Korea developed the Model Checker, a bracket positioned and CRC readymade Core Trays (plastic preformed attachment, perfectly adapted to the external surface of the Ormco lingual brackets).[10]

With the amount of work and development taking place, Lingual Orthodontics will continue to evolve at an accelerating pace, changing the face of Orthodontics.

Patient Selection

The majority of malocclusions can be treated with lingual orthodontics, but certain cases are more amenable than others.[11]

Favourable Cases

- Cases with mild incisor crowding and with anterior deep bite
- Long and uniform lingual tooth surfaces without fillings, crowns, or bridges
- Good gingival and periodontal health
- Keen, compliant patient
- Skeletal Class I pattern
- Mesocephalic or mild/moderate brachycephalic skeletal pattern
- Patients who are able to adequately open their mouths and extend their neck

Unfavourable Cases

- Dolichocephalic skeletal pattern
- Maximum anchorage cases, unless treated with micro implants
- Short, abraded, and irregular lingual tooth surfaces
- Presence of multiple crowns, bridges, and large restorations
- Patients with a low level of compliance

- Patients with limited ability to open the mouth (trismus)
- Patients with cervical ankylosis or other neck injuries that prevent neck extension

Lingual orthodontics is a technically demanding technique and clinicians need to be particularly selective when establishing the suitability of a patient for this form of treatment.

Advantages and Disadvantages of lingual brackets

The lingual appliances have posed a challenging treatment technique for the orthodontists. Some of the advantages and disadvantages of the lingual appliances can be summarized as follows:[12,13,14]

Advantages of the lingual appliances

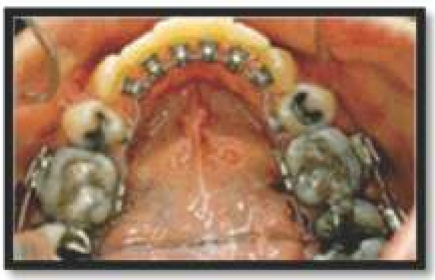
- Aesthetics
- Comfort to the lips and cheek
- Tongue-training effect
- Deprogramming the temporomandibular joint
- Elimination of the visible decalcification
- Elimination of the visible gingival hypertrophy
- Better visualization of tooth alignment
- Better visualization of soft tissue contour
- Rapid bite opening in deep bite case
- Improved patient cooperation
- Decreased breakage
- Reduction in nocturnal bruxism

Disadvantages of the lingual appliances

- Difficulty of direct viewing and access for the orthodontist.
- Difficulty of insertion and removal of archwires
- Variation in morphology of lingual surfaces, especially on the maxillary anterior teeth, may cause unpredicted teeth alignment.
- Wide range of labiolingual thickness of the teeth, necessitating numerous in-out bends.
- Critical relationship between the vertical height of lingual brackets and the labial surface torque, due to the distance of the lingual bracket from the labial surfaces.
- Much smaller interbracket distance in the anterior region, making compensatory bends difficult.
- Precise placement of brackets is more critical than for labial brackets.
- Indirect bonding is required.
- The lingual treatment is more time consuming. Additional chair time is needed.
- Lingual appliances is more expensive.
- Additional laboratory procedure is required.
- Some orthognathic surgery cases require debonding of upper lingual brackets before surgery, such as, segmental osteotomy, open bite correction, class III correction.
- Oral hygiene procedure may be more difficult because of limited accessibility.

BRACKET DESIGN

Kurz Lingual Bracket Design

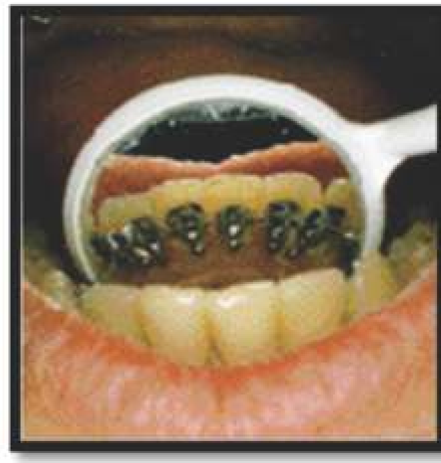


GENERATION #1 — 1976

The first Kurz Lingual Appliance was manufactured by Ormco. This appliance had a flat maxillary occlusal bite plane from canine to canine. The lower incisor and premolar brackets were low profile and half-round, and there were no hooks on any brackets. [15]

GENERATION #2 — 1980

Hooks were added to all canine brackets



GENERATION #3 — 1981

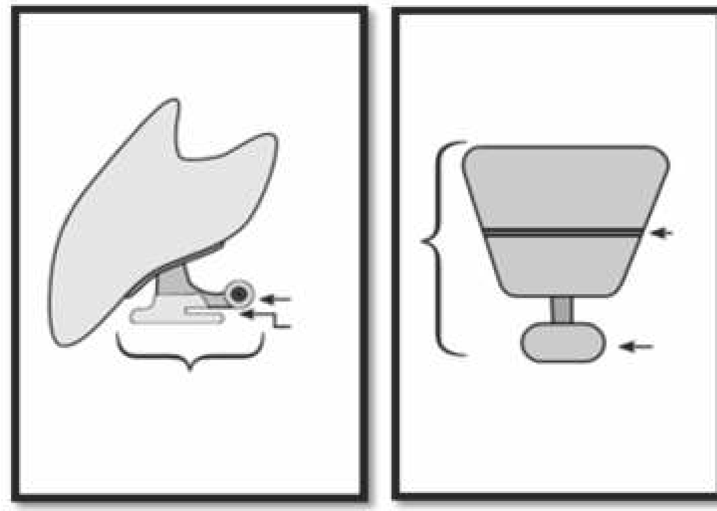
Hooks are present on all anterior and premolar brackets. The first molar had a bracket with an internal hook. The second molar had a terminal sheath without a hook but had a terminal recess for elastic traction.[15]

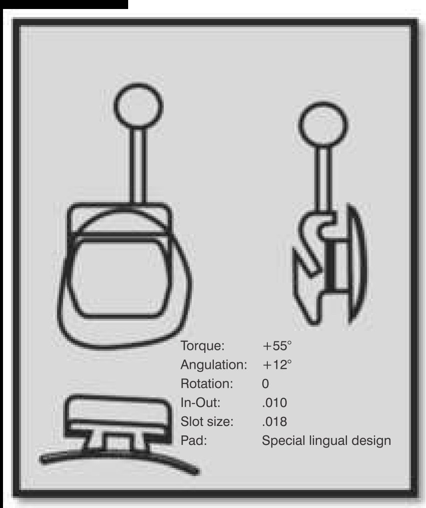
GENERATION #4 — 1982-84

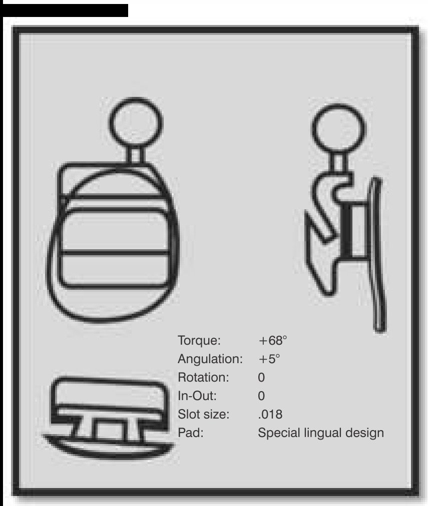
This generation saw the addition of a low profile anterior inclined plane on the central and lateral incisor brackets. Hooks were optional, based upon individual treatment needs and hygiene concerns.[15]

GENERATION #5 — 1985-86

The anterior inclined plane became more pronounced, with an increase in labial torque in the maxillary anterior region. The canine also had an inclined plane; however, it was bibeveled to allow intercuspation of the maxillary cusp with the embrasure between the mandibular canine and the first premolar. Hooks were optional. A transpalatal bar attachment was now available for the first molar bracket. [15]

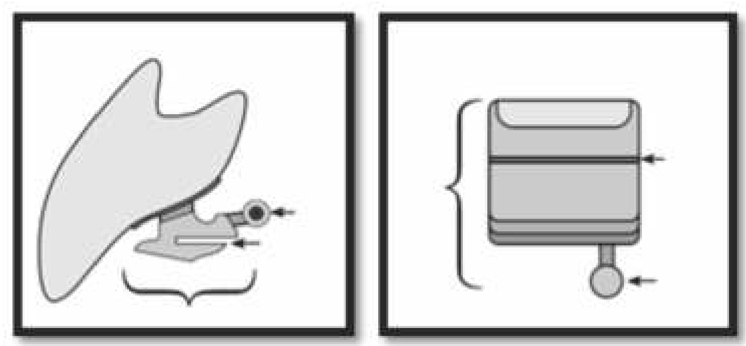






GENERATION #6 — 1987-90

The inclined plane on the maxillary anteriors become more square in shape. Hooks on the anteriors and premolars were elongated. Hooks were now available for all the brackets. The transpalatal bar attachment for the first molar band was optional. A hinge cap, allowing ease of archwire manipulation, was now available for molar brackets.



GENERATION #7 — 1990 TO PRESENT

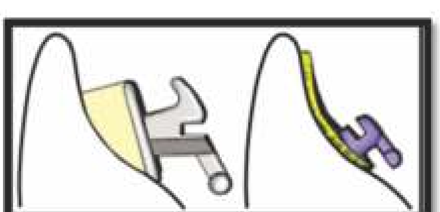
The maxillary anterior inclined plane is now heart-shaped with short hooks. The lower anterior brackets have a larger inclined plane with short hooks. All hooks have a greater recess/access for ligation. The premolar brackets were widened mesiodistally and the hooks were shortened. The increased width of the premolar bracket allows better angulation and rotation control. The molar brackets now come with either a hinge cap or a terminal sheath.

Self Ligating Lingual Orthodontic Bracket(Evolution SLT)

Developed by, HattoLoidl of Germany. It is a self-ligating lingual bracket with a spring clip that allows occlusalarchwire insertion. There are two generations of these brackets, the 2nd generation bracket has a modified stronger arch retaining clip and a reduced buccal-lingual height of the bracket as 2.1mm. The bracket can be opened and closed with a modified scaler, or a special opening instrument. The spring clips are designed as bite planes for lower incisors and have a safety release feature built into them. Any force in excess of 600 grams applied to the bracket, will cause the clip to open, thereby releasing the archwire out of the slot.

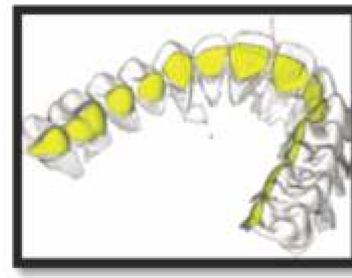
Stb Lingual Brackets

The smallest lingual brackets, called STb, designed by Dr.Scuzzo and Dr.Takemoto (sold by ORMCO). These brackets (1.5 mm thickness) improve greatly the comfort of orthodontic treatment for the patient, giving minimum discomfort in terms of perception of the appliance and creating any speech disturbance. With these brackets, lingual orthodontics is no longer a uncomfortable technique.[7]

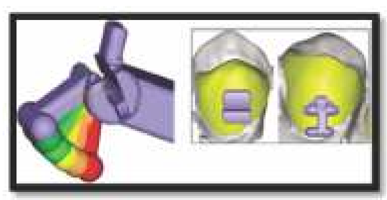


Customized Brackets (Incognito Appliance)

The technique was given by Dirk Wiechmann et al in 2003. Each tooth has its own customized bracket, made with state-of-the-art computer-aided design/computer-aided manufacturing (CAD/CAM) software coupled with high-end, rapid prototyping techniques.[8]



In contrast to conventional lingual brackets, which have standardized mesh bases, a customized "virtual" base is generated on the lingual surfaces of each tooth. Because of the extreme accuracy of the available scan, with a resolution of at least 0.02 mm, the bases are later positively locked with the teeth. The pad surfaces generated are large enough to provide greater bond strength and exact form-fit properties. The bracket base is 0.4 mm thick. The bracket body used here, has an extremely low profile compared with others, guaranteeing absolute control over the tooth and making for a simplified ligation procedure.[8]



State-of-the-art maxillary incisor bracket with vertical insertion direction. Positioning software allows optimum angulation of hook. Accessory occlusal hook is optional.[8]

CONCLUSION

As we are getting more and more adapted to the computerised world having high-tech computer systems, the Incognito appliance system, bracket-positioning software and hardware, and arch wire robotics - the future of orthodontics is brighter with the amount of accuracy being increased due to these superb tools; but to allow the accurate creation of the customized lingual orthodontic appliances, all systems will still rely on accurate, fully detailed individualized prescriptions being written by the orthodontist for input into the computers. This has been the case in the past with more manual systems.

It is essential for practitioners of the lingual technique to use all public relations tools at their disposal to educate the public and general dentists regarding the benefits and advantages of the most successful invisible appliances we have today. Without education, and teaching and promoting our appliances, no matter of which design or how sophisticated they or our laboratory protocols are, lingual orthodontics will not advance at the rate it deserves despite an increased target population.

[redacted]hodontics or invisible [redacted]n efficient, legitimate [redacted]modality that should be [redacted]armamentarium of any [redacted]ring, comprehensive [redacted]c practice. Good results and [redacted]espread acceptance of this [redacted]atment can be [redacted]not just with improved [redacted]ires, and sophisticated [redacted], but also with public [redacted]xercises to win the hearts [redacted]of the general dentist and [redacted]ulation over the [redacted]tion and disinformation [redacted] lingual orthodontics in [redacted]tries.

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OPTICAL COHERENCE TOMOGRAPHY IN DENTISTRY

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ABSTRACT

Optical coherence tomography(OCT), is an emerging technology that can provide tomographic images of the tissue without using X-ray. It uses safe near-infrared light instead of hazardous ionizing radiation. OCT is analogous to ultrasound imaging except that it uses light instead of sound. The optical accessibility of clinically relevant structures in the oral cavity makes it a particularly attractive location for the application of OCT imaging techniques.Optical coherence tomography has a wide range of applications in various fields of dentistry like conservative dentistry, endodontics, periodontics and prosthodontics. Recent advancements are still taking place in imaging and diagnosing epithelial and subepithelial dysplastic changes within the oralmucosal tissues and in the detection of early oral cancer. This non-invasive imaging modality has a promising prospect in dentistry.

KEY WORDS

Noninvasive Optical coherence tomography, Optical biopsy.

INTRODUCTION

Optical coherence tomography (OCT) is an emerging non-invasive imaging modality capable of providing cross sectional imaging of biological tissue. OCT is analogous to ultrasound imaging except that it uses light instead of sound. It can provide cross sectional image of tissue structure on micron scale in situ and in real time. OCT can image through water, saliva and plaque and can record microstructural changes underneath any materials for marginal integrity, bonding interphase, structural fractures, voids and early stages of demineralization beneath occlusal sealants or orthodontic composite brackets. OCT systems can function with a fiber optic probe, they are applicable to almost any anatomic structures accessible either directly, or by endoscopy. OCT has a wide range of potential applications in diagnosing diseases in various structures such as eyes, skin, gastrointestinal, respiratory, genitourinary tract, and the oral cavity.[1]

Otis et al in 2000 developed a dental OCT system which consists of a computer, compact diode light source, photodetector and hand piece that scans a fiber-optic cable over the oral tissues. The system uses a white light fiberoptic Michelson interferometer connected to a hand piece that moves the sample arm linearly to create a tomographic scan.[2]

PRINCIPLES OF OCT

The physical principle of OCT is similar to that of B-mode ultrasound imaging, except that it uses infrared light waves rather than acoustic waves. The in vivo resolution is 10–25 times better (about 10 μm) than with high-frequency ultrasound imaging, but the depth of penetration is limited to 1–3 mm, depending on tissue structure, depth of focus of the probe used, and pressure applied to the tissue surface. OCT devices use a low-power, infrared light with a wavelength ranging from 750–1300 nm in which the only limiting factor is the scattering of light. Scattering occurs when the light interacts with the tissue surface and the image formation depends on the difference in optical back-scattering properties of the tissue.[3] OCT images are generated from measuring the echo time delay and the intensity of back-scattered light. Because the velocity of light is extremely high, optical echoes cannot be measured by direct electronic detection, but by means of a low-coherence interferometry that measures the interference of two incident light beams that are derived from a single source of low-coherence light.[4]

COHERENCE IN OPTICAL COHERENCE TOMOGRAPHY

Optical Coherence Tomography is based on optical interference, as in holography. All OCT systems have a reference arm and a sample arm. The sample arm delivers light to the patient, and collects the light scattered from the patient. This sample light is mixed with light that is reflected from the reference arm of the system.

Coherence refers to a property of light that enhances the detection of the mixing of the sample and reference light. If the sample and reference light are coherent, the mixing produces an interference pattern that is detected in the system and is converted to an image. If the sample and reference light are incoherent; they will not produce an interference pattern that can be converted to an image.

OCT systems are designed so that the reference light and sample light are only coherent when the path lengths are very closely matched. Generally, the reference arm position is changed to image different subjects, such as the retina (back of the eye) and the cornea (front of the eye).[4]

TOMOGRAPHY IN OPTICAL COHERENCE TOMOGRAPHY

OCT is a good technique for creating cross-sectional (tomographic) or volumetric pictures of an object. Such a picture is produced by scanning light across the subject to be imaged.

A-Scan

A-scan, also called as axial scan. The information obtained corresponds to the depth of the tissue which is determined by the optical reflectance of the tissue. The image of the subject that is produced along the depth direction is termed an A-scan. Each A-scan provides information about the reflective or scattering properties of the subject as a function of depth at one position of the scanned beam.[1]

B-Scan

B-scan or longitudinal scan is generated by collecting many single axial scans linearly across the tissue and in subsequent transverse positions. The images obtained will have both depth axis and lateral or angular axis. Collection of many such parallel B-scans can be used for 3D data acquisition.

A cross-sectional image is produced by assembling a collection of neighboring A-scans. This is the **tomography** in OCT. Typically, we think of a B-scan as being an image of a planar slice into the subject, as if we had used a scalpel to cut into tissue. But a **B-scan** does not have to be a planar image. It is common to take an image along a circle as well, and this cross-sectional view is then an annular scan around a point of interest in the tissue.[5]

A volumetric image is constructed from a collection of B-scans. There are three major types of volumetric images used in OCT imaging:

- Rectangular, or faster volume scan: A series of parallel B-scans
- Radial volume scan: A series of B-scans at regular angular intervals
- Annular volume scan: A series of B-scans forming concentric rings

T-Scan

T-scan or en-face scan is produced by transversally scanning the beam over the target maintaining the reference mirror fixed to generate a reflectivity profile in an angle or lateral position.[5]

C-Scan

C-scan, also called as transverse slice scans, are made from many T-scans in the transverse plane. Different transversal slices are collected for different depths either by advancing the optical path difference in steps after each complete transverse scan, or continuously at a much slower speed.[5]

In OCT, two-dimensional, cross-sectional images of tissue microstructure are constructed by scanning the optical beam and performing multiple axial measurements of back-scattered light at different transverse positions. The resulting dataset is a two-dimensional array that represents the displayed image as a grayscale or false-color image.[4]

DENTAL APPLICATIONS OF OCT

Dental caries

Presently, diagnosis of carious lesions are mainly through visual and radiographic examination. Unfortunately, the former does not detect the noncavitated lesions, whereas the latter known for its high sensitivity and specificity for diagnosing primary caries are highly invasive and less reliable in the detection of early caries.[6]Dental OCT directly addresses the image quality issue with its intrinsic high resolution and contrast mechanism, which is useful to identify tiny precaries and fissure lesions before their potential progression to serious dental decay.[1]OCT is a method that allows qualitative and quantitative information, such as demineralization depth and size, to be obtained through 3D images.[6]Using Optical Coherence Tomography (OCT), dentists are able to diagnose sound and demineralized teeth with lower rates of false positives and false negatives than clinical or radiographic examination.[7]

Endodontic therapy

OCT outsmarts endoscopes through its small diameter and increased flexibility of the probe. In addition, OCT imaging does not require dry root canal and they provide a characterized microscopic detailed image through the surrounding root canal circumferential from dentin to cementum. Such measurements are capable of indicating the exact thickness of the dentinal wall and can aid indetermination of minimal dentin thickness to prevent root canal over preparation and possible perforation of canal walls. Intraoperatively, OCT imaging of root canals can indicate uncleaned fins, transportation of the canals, hidden accessory canals and measurement of the apex. A controlled blind OCT endodontic study concluded that OCT is a valuable tool for imaging and identifying vertical root fractures and detecting the fracture location.[8]

Periodontal disease

OCT can provide excellent images of the periodontal soft tissue attachment, contour, thickness and depth of the periodontal pockets. To evaluate the efficacy of OCT in vivo imaging of periodontium, Otis et al in 2000 performed a study among healthy adults with no clinical evidence of gingivitis or periodontal disease. The dental OCT system consisted of 140 μW, 1,310 nm super luminescent diode light source which can detect up to 70 femto watts of reflected light. It has an imaging depth of approximately 3 mm; with an image acquisition time of 45 seconds. The authors concluded that the in vivo dental OCT images clearly depicted periodontal tissue contour, sulcular depth and connective tissue attachment. In addition, the authors stated that as OCT reveals microstructural detail of the periodontal soft tissues, it offers the potential for identifying active periodontal disease before significant alveolar bone lossoccurs.[8]

Prosthodontics

The dental prosthesis incorporates various materials, such as acrylics, ceramics, polymers, composites and metals, which are bridged and bonded together. The prostheses are more prone for fractures due to masticatory stress or it can be triggered by defects in the processing of the materials leading to micro leakage. OCT is employed for evaluation of microleakage.[8]

Evaluation of Mucosal Changes

Optical coherence tomography (OCT) is a high-resolution optical technique that permits direct immediate imaging of the oral epithelium – on the surface and at depths 2-3mm. It will be advantageous to use OCT for assessment of tissue injury during radiation therapy. OCT imaging can offer 3D imaging of tissue microstructure in situ and in real time without requiring a transducing medium and contrast enhancing agents while achieving spatial resolution approximately as the same depth of conventional biopsy.[9]

Optical Biopsy – An Emerging Modality

Over past decades, researchers have investigated the possibility of developing a realtime, in situ, non-invasive technique that can aid in the diagnosis of abnormal tissue (i.e. inflammation, hyperkeratosis, is chaemia, metaplasia, dysplasia and neoplasia). The use of light optical biopsy in the diagnosis of tissue pathology represented a leapinto the future. The aim was to develop a technique that could act as an adjunct or even replace histopathology and thus reduce surgery. Optical biopsies can be acquired through different modalities; each has its own mechanism of action and requires different modes of data analysis. Several optical diagnostic techniques have been employed with variable success rates. The main techniques currently utilised in the detection of oral dysplasia are fluorescence, Raman spectroscopy, micro endoscopy, elastic scattering spectroscopy and optical coherence tomography.[1] In vivo image acquisition is facilitated through the use of a flexible fiberoptic OCT probe, which is simply placed on the surface of the tissue to generate realtime, immediate surface and sub-surface images of tissue microanatomy and cellular structure, whilst avoiding the discomfort, delay and expense of biopsies. Because image resolution can be as good as 5um, these images provide an excellent indication of the most important sites for surgical biopsy. With the advent of even faster and higher resolution OCT systems, this imaging data may well replace the need for biopsies in many situations in the foreseeable future.[10]

Histopathology continues to be the complementary objective 'gold standard' in the diagnosis of abnormal oral lesions. Optical coherence tomography imaging of suspicious oral lesions could improve the diagnostic accuracy for oral dysplasia and the differential diagnosis between neoplastic and non-neoplastic lesions.[11]

Pre-malignancy and Oral Cancer

Early detection and management of pre-malignant oral lesions can significantly reduce the progression of these lesions into invasive cancer, and would thus reduce morbidity and mortality. This is usually augmented by patient counseling and advice on the reversal of habits that increase the risk of developing cancer (e.g. smoking and drinking).[12]

A pre-malignant lesion is always at risk of malignant transformation if certain exogenous factors or conditions persist. Regular monitoring of these lesions is mandatory; when suspicious of neoplastic transformation, a biopsy may be required. This can be uncomfortable, time-consuming, costly and stressful to the patient while waiting for the diagnosis.

Often multiple lesions may not all be visible to the naked eye, preventing their detection and diagnosis. The inability to delineate lesion margins visually provides an additional diagnostic and therapeutic challenge. OCT can clearly distinguish many histologic features such as epithelial and sub epithelial change.[5](Fig 1,2) 3-D images provide detailed structural information at any location, and may be viewed at any angle desired by the clinician. The appearance of structures imaged by OCT corresponded closely to histologic images.[4]In 2009; Wilder-Smith studied 50 patients with dysplastic and malignant oral lesions and found OCT to have 93.1% sensitivity and 97.3% specificity for detecting SCC versus all other pathologies with an excellent intra- and inter-observer agreement.[13]

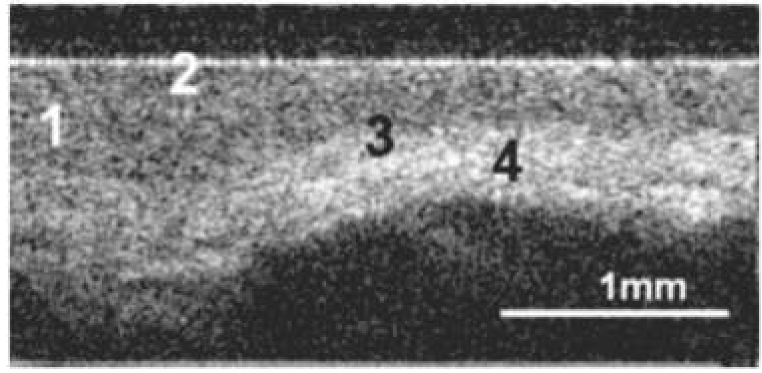

Fig 1: In vivo OCT image of normal buccal mucosa. (1) Stratified squamous epithelium, (2)keratinized epithelial surface layer, (3) basement membrane, (4) submucosa.

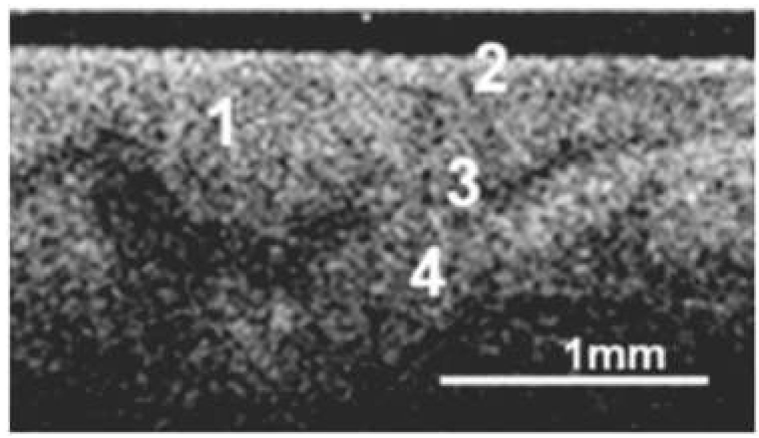

Fig 2: in vivo OCT image of dysplastic buccal mucosa.

ADVANTAGES OF OCT

The sensitivity advantage is transferred to high-speed dental imaging acquisition in vivo, which is an important prospective in dental clinic practice. When imaging a non-stationary target, i.e. a patient, high speed is required to reduce the motion smearing and thus retain the high resolution property of the imager. Meanwhile, shorter scan duration is necessary to reduce the discomfort of patients especially children. Current state of the art OCT scanning speed would enable a single scan of one tooth surface within a couple of seconds. With such an imaging paradigm, we have a true 3D dental scan to cover the full surface area of teeth. This opens options for more quantitative and comprehensive diagnostic approaches.[1]

DISADVANTAGES OF OCT

- Lack of resource and lack of knowledge in practitioners about OCT.
- Insufficient depth.
- Expensive investment

CONCLUSION

OCT is a young, non-invasive imaging method that provides high-resolution,cross-sectional images of the most superficial tissue layers and that seamlessly integrates into other diagnostic procedures. It has shown highly promising results in smaller clinical studies which have applied OCT for the diagnostic workup of superficial pathologies. OCT has the potential to become a powerful method for early oral cancer detection. This non-invasive imaging modality has a promising prospect for dentistry.

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THE THREE DIMENSIONAL ROOT CANAL TREATMENT WITH SAF (SELF-ADJUSTING FILE) - A LITERATURE REVIEW

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ABSTRACT

The primary aim of root canal treatment is to completely clean and shape the root canal system. Various instruments are available for endodontic instrumentation. Although rotary systems do prepare many canals without major procedural errors but they do not address canal types with long-oval or flat cross section as not all root canals are round in shape.

A newly designed Self Adjusting File (SAF) was designed to address the shortcomings of traditional rotary files by adjusting itself to the canal cross section. The SAF is hollow and designed as a thin cylindrical nickel-titanium lattice that adapts to the cross section of the root canal. A single file is used throughout the procedure. The SAF is used in an in-and-out motion powered by a handpiece and under constant irrigation.

With the introduction of adaptive cleaning, shaping, and disinfection using the SAF Endo System, the reduced effectiveness of rotary filing and their potential for procedural mishaps can be eliminated.

KEY WORDS

Self Adjusting File, nickel-titanium, constant irrigation, adaptive cleaning.

INTRODUCTION

The most important objective of root canal treatment is cleaning and shaping of the root canal system[1,2]. Original root canal path should be maintained and the root canal wall dentin should be cut circumferentially so that prepared root canal wall outline reflects the original outline[1].

Many varieties of instruments are available in the market today for root canal instrumentation. Beginning with hand files which was used for many years[3], traditionally these instruments were made out of stainless steel[3,4] but during the last decade nickel-titanium instruments have been developed to facilitate root canal instrumentation[5]. Over the years many endodontic instrument system have been manufactured from nickel-titanium with specific design characteristic variations like tip size, cross section, helix angle, pitch and taper. But in flat oval canals rotary file systems may be difficult to instrument the entire wall of oval canals and often fail to adequately clean and shape the canal[6].

The Self Adjusting File- the new concept in cleaning and shaping was developed to overcome the inherent remaining problems of the nickel-titanium instruments[7].

Self-Adjusting File – Design

(ReDent Nova, Ra'anana, Israel)

The SAF is hollow and designed as a thin cylindrical nickel-titanium lattice that adapts to the cross- section of the root canal[7].

Fig 1: The SAF is a hollow file designed as an elastically compressible, thin-walled pointed cylinder, 1.5 mm in diameter, composed of a thin nickel-titanium lattice

The file is surface treated to create an abrasive surface, which enables it to file dentin from the canal's interior surface.

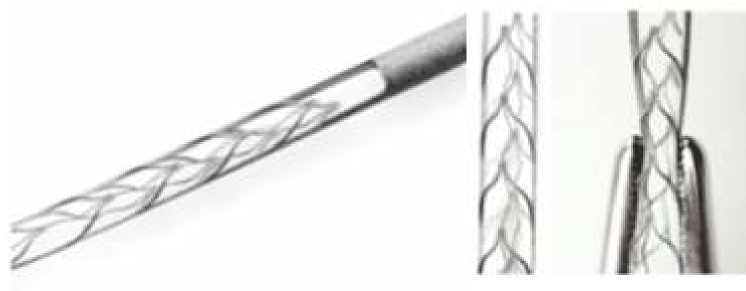

Fig 2:The abrasive surface of the SAFwill achieve gradual enlargement of the root canal. The SAF is extremely flexible and pliable (magnified view, left). It does not impose its shape on the canal, but complies with the canal's original shape, eliminating the risk of transportation and strip perforation accidents

SAF adapts itself to the canal's original anatomy and shape providing three-dimensional adaptation during cleaning and shaping process.

The open lattice structure of the device design permits continuous irrigation during procedure without increasing intracanal pressure.

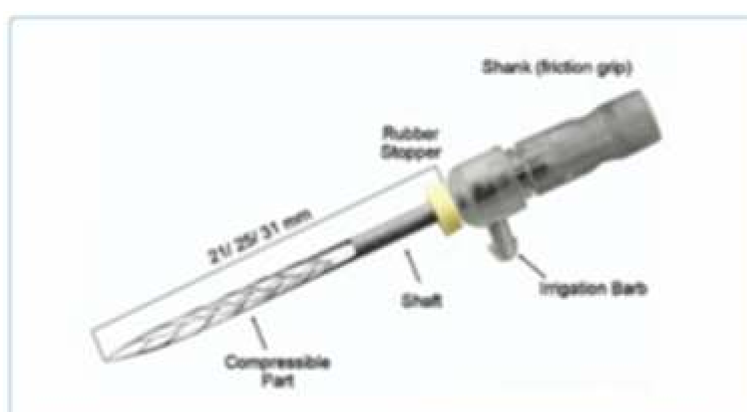

Fig 3:Parts of Self Adjusting File.

The shank connects to the handpiece by means of friction grip. The irrigation barb connects to a tube delivering irrigant.

The SAF is available in two diameters; 1.5mm and 2mm.

The SAF 1.5mm is available in three standard lengths- 21mm, 25mm, 31mm whereas the SAF 2mm is available in two lengths-21mm and 25mm.

Fig4:Available in three lengths(21 mm, 25 mm, and 31 mm), the SAF is used as a single instrument to complete 3-D root canal shaping and cleaning.

Operation of SAF

SAF is inserted into a path initially prepared by a #20 K file and operated with a trans line-(in and out) vibration in an KaVo GENTLE power hand piece with RDT3 head.

Fig 5:The SAF fits into a special handpiece, which provides the trans line (up-and-down) motion of the SAF with the simultaneous and continuous flow of irrigant

The resulting circumferential pressure allows the file's abrasive surface to gradually remove a thin uniform hard tissue layer from the entire root canal surface resulting in a canal with a similar cross section but of larger dimensions. This holds good even for canals with an oval or flat cross-section, which will be enlarged to a flat or oval cross-section of larger dimensions.

The hollow SAF is operated with a constant flow of irrigant that enters the full length of the canal and is activated by the vibration and is replaced continuously throughout the procedure without increasing the intracanal pressure. This results in effective cleaning even at the cul-de-sac apical part of the canal.

SAF instrumentation is intended to be used with a continuous, gentle, up and down, “hand pecking” motion of 3-5mm range as the specialized handpiece head generates a consistent oscillation. Most of the dentin removal occurs within the first two minutes of operation, however after the recommended four minutes of SAF cleaning and shaping , the apical third of the canal will have been enlarged approximately 3-5 ISO sizes[8].

QR CODE - Scan this QR code on your smart phone to watch the SAF in action.

The SAF has been shown to be superior to rotary files in its durability[8]. However SAF instrument is intended for single use only. SAF has a tendency to cause less dentinal cracks as compared to ProTaper and Mtwo[9].

Deformation of SAF occurs as detachment of one of the arches or struts at connection points, in no case so far did its mechanical failure result in metal fragment retention in the root canal[10].

Challenges; Curved, non- rounded canals, Retreatment

Curved canals are a significant challenge to the chemo-mechanical preparation of root canal system. The SAF has significantly more contact to the dentin walls, removes more debris than rotary instrumentation in the apical third of oval shaped root canals, C-shaped root canals and it is promising approach in endodontic treatment of these type of canal morphology[11, 12].

Additional use of SAF after the retreatment procedures may improve root canal cleanliness in the coronal and middle thirds of oval root canals[13].

The SAF system produced a smear layer when using 3% sodium hypochlorite alone; but when alternated with application of 17% EDTA, the canals were rendered virtually free of debris and smear layer with the most pronounced benefit realized in the apical third of the root canal[14].

Obturation

Root canal obturation is an essential component of RCT, which aims to prevent future bacterial contamination and recontamination of the canal space in a study[15] comparing the obturation efficacy between canals cleaned and shaped with rotary files and the SAF system, lateral compaction of guttapercha cemented with AH26 was evaluated. The results revealed the SAF system allowed as much as 83% of the canal wall to have intimate contact with the obturation material compared to only 55% for rotary files.

Because of the irregularly shaped canals prepared using the SAF system, instead of the traditionally tapered shaped canals, obturation may be more challenging; however, any of the current obturation techniques may be employed, including lateral compaction, carrier based obturation and warm vertical compaction.

After SAF instrument use, the apical canal shape should be measured by apically gauging with hand files(usually#30 or #35 file should go to full WL). Subsequently the master cone or carried based obturator of the corresponding size is selected and cemented to WL using any of the above mentioned obturation technique.

CONCLUSION

Cleaning, shaping, and disinfection of the root canal system are the most important steps in endodontic treatment. Currently, endodontic procedures are performed with hand and rotary instruments that do not adapt to the canal walls and deliver very little fresh irrigant to the root canal space, especially the apical third. Unfortunately, the literature is replete with examples of instrument breakage, poor results with chemo-mechanical preparation, canal transportation, and over-thinning of the canal walls. Because hand and rotary files are round in cross-section, they often leave more than half of the canal walls untouched and require multiple sequences of filing and irrigation, all reducing the efficacy of canal obturation techniques. With the introduction of adaptive cleaning, shaping, and disinfection using the SAF Endo System, the reduced effectiveness of rotary filing and their potential for procedural mishaps can be eliminated. Adaptive SAF instruments can conform to the natural shape of each canal, moving in an oscillating up-and-down movement while providing simultaneous irrigation. After establishing the glide path to WL, just one SAF is required to homogenously and circumferentially prepare the canal walls.

This paradigm-shifting technology is now in world-wide use, and promises to improve treatment outcomes.

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TORUS PALATINUS AND MANDIBULARIS – REVISITED

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ABSTRACT

While there is a hereditary component to tori, this does not explain all cases. Tori tend to appear more frequently during middle age of life; the torus palatinus is more commonly observed in females, but this is not the case with the torus mandibularis. Certain ethnic groups are more prone to one torus or the other. The torus is mainly removed due to prosthodontic reasons, as it may also be used as biomaterial, not only in periodontology, but also in implantology. The clinical importance of exostosis lies in surgical removal of these to permit proper flap adaptation, most importantly in the posterior maxilla, and to the potential use of the mandibular and palatal tori as sources of autogenous cortical bone for grafting.

KEYWORDS

Tori, Torus Mandibularis, Torus Palatinus.

INTRODUCTION

Under the general term exostoses are described non pathologic, localized bony protuberances that arise from the cortical bone and sometimes from the spongy layer.[1] Such developmental anomalies, or hamartomas, are not pathologically significant, and they most frequently develop in the human jaw bone. Two of the most common exostoses that occur in two specific intraoral locations - on the midline of the hard palate and on the lingual aspect of the mandible in the cuspid/ premolar region--are termed torus palatinusand torus mandibularis respectively.[1,2]

The tori (meaning “to stand out” or “lump” in Latin) are exostoses that are formed by a dense cortical and limited amount of bone marrow, and they are covered with a thin and poorly vascularized mucosa. Castro Reino et al defined it as a congenital bony protuberance with benign characteristics, leading to the“overworking” of osteoblasts and bone to be deposited along the line of fusion of the palate or on the hemi mandibular bodies.[3]

HISTORY

In the literature it is noted that an exostosis of the hard palate was first observed and reported by Santorini[4] in 1724, whereas the earliest article describing the exostotic changes of the hard palate was written by Fox[4] in 1814. Carabelli provided a detailed description of palatine torus in 1842 and even suggested a familial tendency for trait expression. Although the trait had been described under various names early in the 19th century, the term torus palatine was coined by Kupffer and Bessel-Hagen in 1879 in a letter addressed to Virchow. It was further claimed that it was characteristic of East Prussian skulls. Late- 19th- and early-20th-century researchers associated palatine torus with syphilis, tuberculosis, rickets, scurvy, cancer, insanity, and criminality and even with the regularity of sexual activity.[2] In the 20th century biologists made a concerted effort to include palatine torus in textbooks of oral anatomy.[5]

Torus mandibularis was first described by Danielli in 1884; however, the term was first used in 1908 by First, who used it to denote a bony protuberance that developed on the lingual surface of the mandible, most often in the premolar and canine areas.[2]

PREVALENCE

Prevalence of palatal tori ranges from 9% - 60% and are more common than bony growths occurring on the mandible, known as torus mandibularis. Palatal tori are more common in Asian, Native American and Inuit populations, and twice more common in females. Mandibular tori are more common in Asian and Inuit populations, and slightly more common in males.[6]

ETIOLOGY

Currently, tori are considered to be an interplay of genetic and environmental factors with a familial occurrence suggesting autosomal dominant inheritance with reduced penetrance.[7] Suzuki and Saki[8] suggested the two anomalies are due to the same autosomal dominant gene.

Alvesalo suggested sexual dimorphism in the manifestation of torus mandibularis might result from the effect of Y chromosome on growth, occurrence, expression, and timing of development of mandibular tori.[9] The role of nutrients in the etiology of tori has been recently reviewed by Eggen et al.[10] who suggested saltwater fish consumption in Norway possibly supplies higher levels of polyunsaturated fatty acids and Vitamin D that is involved in bone growth which increases the chances of tori.

CLINICAL PRESENTATION

Tori occur most frequently in adults aged 35 to 65 years.[11] In most cases, the finding is usually incidental and observed during clinical examination at the dental office. This is because they are asymptomatic for the most part, and those who have torus are not aware of it.[12] They are diagnosed by clinical examination: The torus palatinus can be unilobular, polylobulated, flat and spindle-shaped, located at the midline of the hard palate.[13] (Fig 1) The torus mandibularis are usually symmetrical and bilateral, but can also be unilateral, located on the lingual side of the mandible, above the mylohyoid line and at the level of the premolars.(Fig 2) Sometimes patients may present phonatory disturbances, limitation of masticatory mechanics, ulcerations of the mucosa, food deposits, prosthetic instability, obstructive sleep apnea and some patients may experience cancerophobia, and consult a professional in order to look for a solution.[12] Rarely may tori be associated with exostosis, unerupted mandibular canines, sclerosteosis, or parafunctional activity.[14,15] However, the presence of tori might be advantageous since they may be used as sites for harvesting bone for ridge augmentation procedures to replace a missing tooth and the potential use of the mandibular and palatal tori as sources of autogenous cortical bone in periodontal surgery. Torus mandibularis might be useful as an indicator of increased risk of temporomandibular disorders in some patients.[13,16] Sasaki reported an association between palatal and mandibular tori and chronic phenytoin therapy.[17]

Radiological examinations reveal radiodense images with a slightly higher density than that of the surrounding bone. Carrying out radiographic procedures (periapical, occlusal, and panoramic) is not very useful, given the simplicity of the diagnosis during clinical examination.[3]

Histopathological examination reveals that it is similar to the compact structure of the normal bone, having a slightly spongy structure with marrow spaces, bone tissue shows the presence of lacunae and normal osteocytes along with scattered spaces of connective tissue containing dilated vessels.[1]

Fig 1: Torus palatinus

Fig2: Torus mandibularis

TREATMENT

Removal of the tori is not always necessary. The most frequent cause of extirpation continues to be the need for prosthetic treatment or that of being a potential source of autogenous cortical bone for grafts in periodontal surgery, cyst surgery or implant surgery, although long-term stability of the grafts is uncertain.[13,18,19]

Following are the indications for surgical removal of tori[3]:

i. Disturbances of phonation
ii. Limitation of masticatory mechanics
iii. Sensitivity due to the thin mucosa layer
iv. Traumatic inflammation
v. Esthetic reasons
vi. Prosthetic instability
vii. Source of autogenous cortical bone for grafts
viii. Food retentive areas

Following are the post-operative complications of the tori[3]:

i. Hematoma
ii. Edema
iii. Opening of a suture
iv. Infection
v. Bone and mucosal necrosis

vi. Neuralgia
vii. Poor scarring

POST-OPERATIVE CARE

The patient must be informed that the signs and symptoms that may occur during the postoperative period will be those that are most commonly associated with this type of surgical procedure, such as edema, hematoma, mild pain, etc. Postoperative medication will consist of antibiotics, analgesics and anti-inflammatory medicine, as well as stressing that it is important for the patient to continue with appropriate personal hygiene so that the wound may heal properly.[12]

CONCLUSION

Palatal and mandibular tori require no treatment unless they become so large they interfere with function, denture placement, or suffer from recurring traumatic surface ulceration. When treatment is elected, the lesions may be surgically removed. Slowly enlarging, recurrent lesions occasionally are seen, but there is no malignant transformation potential. A patient should be evaluated for Gardner syndrome if they present multiple bony growths or lesions not in the classic torus locations. Intestinal polyposis and cutaneous cysts or fibromas are other common features of this autosomal dominant syndrome.

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