

Device for tooth extraction

Product design project II

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Acknowledgements

I express my gratitude to my guide Prof. Vijay Bapat for constantly motivate me and pushing me towards Learning new things which will make project progress in required direction. And constant supply of “food for thought” product from their personal collection which have always inspire me to do some thing good. I would like to thank them to make me learn design process and their application with various design tools.

I would like to thanks Dr. Shrungesh Shah for their constant support from medical field for validation and other medical input support. and also like to thanks Dr. Rohide for their input and knowledge shearing with us regarding tooth extraction.

And at last I like to thanks my friends and classmates for constant support and motivation for completion of project and supporting me with critical input and brainstorming .

A handwritten signature in blue ink, reading "Amy Damjee", is centered on a white rectangular background. The signature is written in a cursive, flowing style.

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Introduction

Tooth extraction is basically the removal of a tooth from the alveolar bone cavity. It could be simple or complex process depending on the tooth it to be extracted.

The tooth is extracted with several reasons majority of them are unrestorable tooth decay, periodontal disease or dental trauma and impacted wisdom tooth.

Tooth extraction is usually done keeping individual awake by using local anesthetic injections to eliminate painful sensations in a local area. Local anesthetic blocks pain, but mechanical forces are still felt.

Removal of some tooth's become really difficult with several reasons, some of them are position of tooth orientation of tooth, root shape size, and orientation, integrity of tooth and bone.

A dental branch which primarily deals with tooth extraction is oral surgery or exodontist but general dentist and periodontists often carry out tooth extraction. As they perform tooth extraction they also perform implant placement.

Introduction

Tooth anatomy

Name used for upper jaw is maxillary and for lower jaw is mandibular; human jaw has 8 incisors, 4 canines, 8 premolar and 12 molars.(as shown in figure1.1)

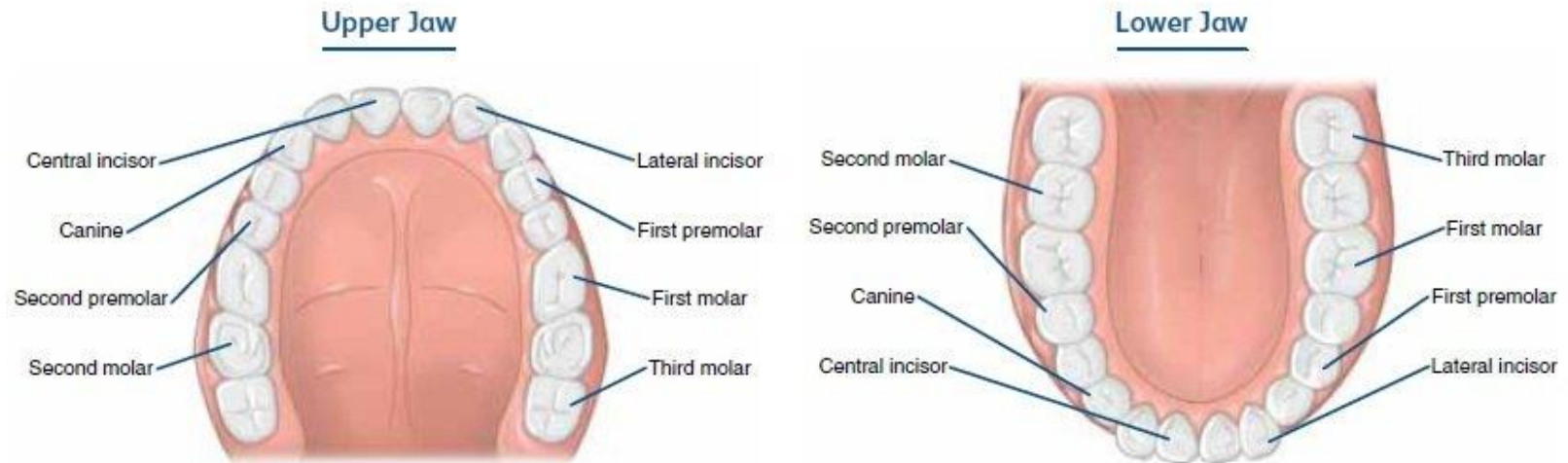


Figure 1.1 Tooth Structure

Source- <https://goo.gl/r6jGnG> (as seen on 20.08.17)

Introduction

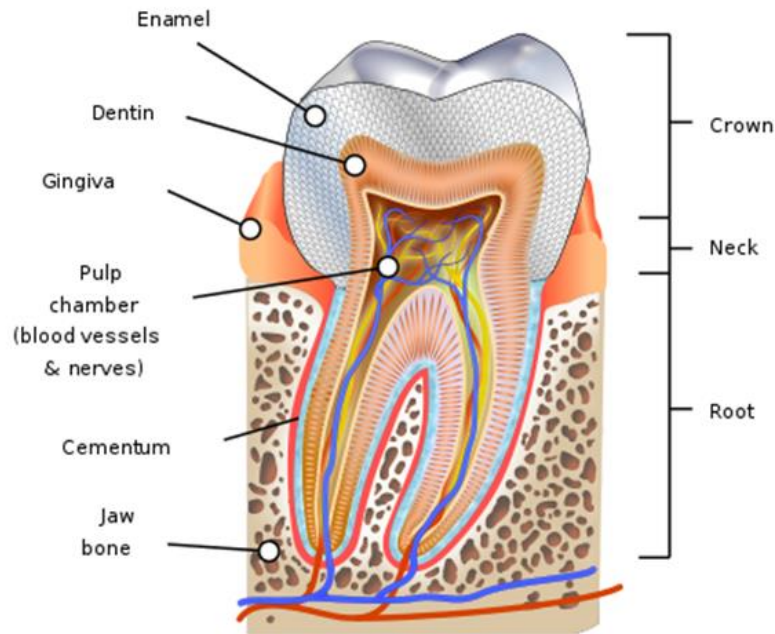


Figure 1.2 Tooth anatomy

Source-

https://en.wikipedia.org/wiki/Human_tooth#/media/File:Human_tooth_diagram-en.svg(As seen on 25.8.17)

A tooth is composed of 3 mineralized tissues the enamel, the dentin and the cementum and pulp (shown in given figure1.2).

- Enamel

Enamel is the hardest substance in the human body. enamel is only on the crown part of the tooth

- Dentin

Dentin is below the enamel and major chunk of the tooth dentine is softer than the enamel compensating the brittleness the enamel. Dentist is not visible unless tooth is decayed

- Cementum

Cementum is a thin layered hard tissue that covers the roots of a tooth. It gives attachment to the periodontal ligaments

- Pulp

Dental pulp is connective tissue that carries blood and nerve supply to the tooth. It is present at the core of the tooth. The pulp is surrounded by the dentin and the portion of it is in crown called pulp chamber which also called a root canal. During root, canal pulp is removed completely from tooth cavity.

Introduction

Supporting structure

The periodontium is the supporting structure of a tooth. It consists of the cementum, periodontal ligaments, alveolar bone, and gingiva. Periodontal ligaments connect the alveolar bone to the cementum as is shown in the adjacent figure. Over the bone which is visible is gum or gingiva.

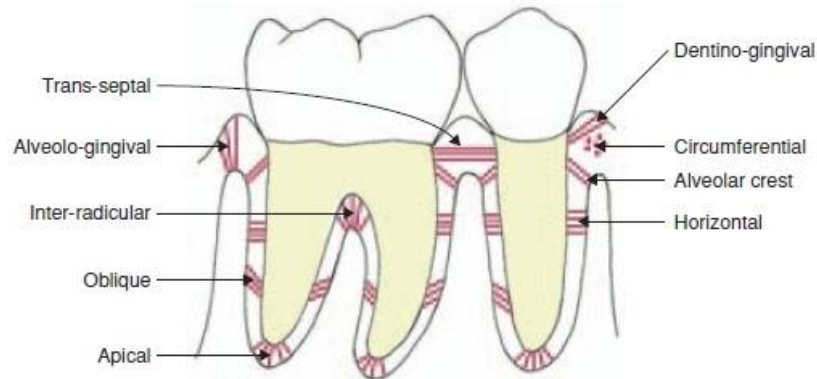


Figure 1.3 Tooth anatomy

Source- <https://goo.gl/1N8cCT>(As seen on 25.08.17)

- **Periodontal ligaments**
The periodontal ligaments are the connecting linkages to the tooth and the alveolar bone also called as PDL, periodontal ligaments also carry sensation from tooth .when tooth exert forces as in chewing or biting periodontal ligament will be in compresses and subsequent sensations passed through nerves. PDL is of 0.15 to 0.38 mm width of size and size of ligament will reduce with time.
- **Alveolar bone**
The alveolar bone which supports the tooth and surrounds the tooth for anchoring, as alveolar bone is having higher no of osteoblast cells, they can deform and form fast as compare to normal bone.
- **Gingiva**
the gingiva is gum tissue which covers the alveolar bone and most of the jaw. Gums or gingiva are touches to the tooth but not attached to it.

Literature review



Figure 2.1 Fractured tooth

Source- <https://goo.gl/EoFH82> (As seen on 10.09.17)

Reasons for tooth loss/extraction

Following are some of the conditions where it may be difficult to save the tooth:

- A fractured tooth which cannot be restored (fig.2.1)

when a tooth has fractures till the root of the tooth as shown in the figure it becomes difficult to restore in that case to reduce further pain and problems tooth are extracted.

- A tooth which is affected by infection (fig.2.2)

when tooth roots are affected by infection as is shown in the figure and reaching the bottom of the root becomes difficult to access the infection then the tooth is extracted and infection is cleaned.

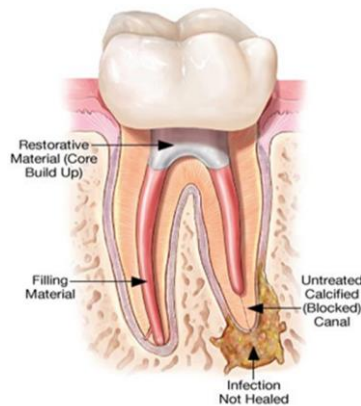


Figure 2.2 Tooth Infection

Source- <https://goo.gl/ySW4wP>(As seen on 10.09.17)

Literature review

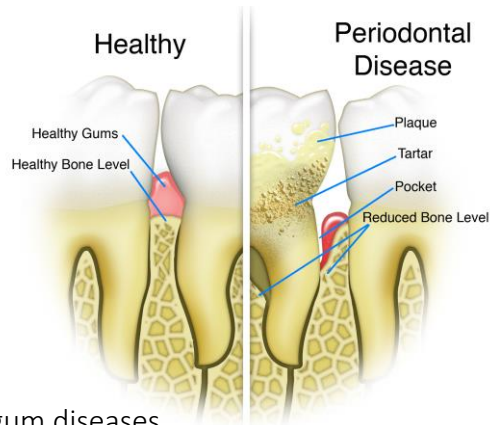


Figure 2.3 gum diseases

Source- <https://goo.gl/3Eeh3d>(As seen on 10.09.17)



Figure 2.4 baby teeth that remain leading

Source- <https://goo.gl/oG92Up> (As seen on 10.09.17)

- Severe caries or gum diseases(fig.2.3)

Plaque consists mostly of bacteria. As a number of bacterial plaque increases, the tooth is more vulnerable to dental caries when carbohydrates in the food are left on teeth after every meal or snack. Yellow portion in the figure shows plaque

- Baby teeth that remain leading (fig.2.4)

Permanent tooth develop during the embryonic stage of development and milk tooth are usually lost and replaced by permanent teeth, but in the absence of permanent replacements, baby teeth or milk tooth can remain functional for many years. While eruption of the permanent tooth they can create a problem or creates resistance to grow, resulting in ingrown tooth under the milk tooth uneven arrangement of the tooth.

In figure its seen that permanent teeth's are growing below milk teeth.

Literature review



Figure 2.5 orthodontic problem

Source- <https://goo.gl/gSg5nv>(As seen on 10.09.17)



Figure 2.6 orthodontic problem

Source- <https://goo.gl/gSg5nv>(As seen on 10.09.17)

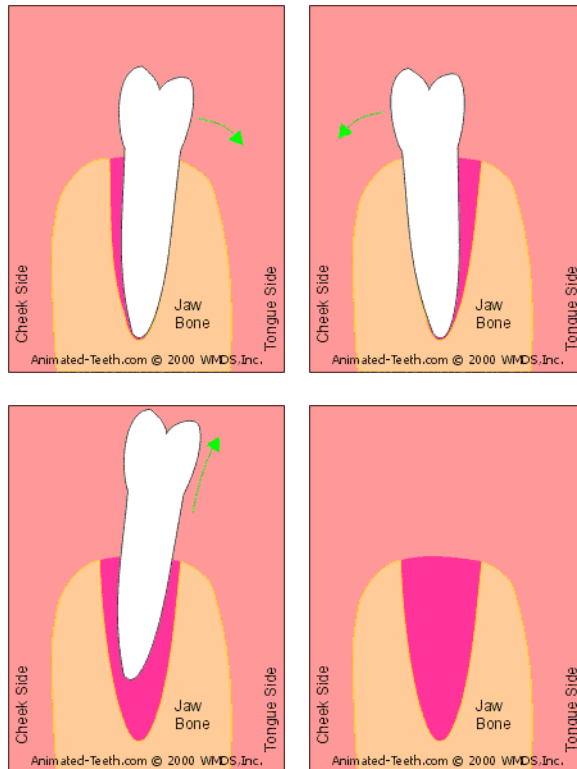
- Serious orthodontic problems(fig.2.5)

A bad bite can also be caused by thumb or finger-sucking, mouth breathing, dental disease, abnormal swallowing, poor dental hygiene, the early or late loss of baby teeth, accidents or poor nutrition. Trauma and other medical conditions such as birth defects may contribute to orthodontic problems, which is abnormal growth of tooth extra tooth on the misalignment of the tooth, in some cases, orthodontic problems need tooth to be extracted.

- Wisdom Teeth also called as third(fig.2.6)

wisdom teeth grow in inclined direction disturbing the healthy tooth and creating a problem, the eruption of wisdom tooth itself painful process in some cases it has to be removed to reduce pain.

Literature review



The extraction process –

When a tooth is pulled, here's the situation that a dentist faces.

- The root portion of the tooth is firmly encased in bone, and tightly held in place by its ligament (PDL).
- To remove the tooth, the dentist must both "expand its socket" (widen and enlarge it) and separate it from its ligament.
- The bone that encases a tooth's root is relatively spongy.
- And due to this characteristic, when a dentist firmly rocks it back and forth against the walls of its socket, the bone compresses.
- After repeated cycles of side-to-side pressure, the entire socket gradually increases in size (expands). (See figure 2.7)
- Finally, a point is reached where enough space has been created (and simultaneously the root's ligament torn away enough) that the tooth can be removed easily.

Figure 2.7 extraction process

Source- https://www.animated-teeth.com/tooth_extractions/t5_extracting_teeth.htm(As seen on 25.09.17)

Literature review

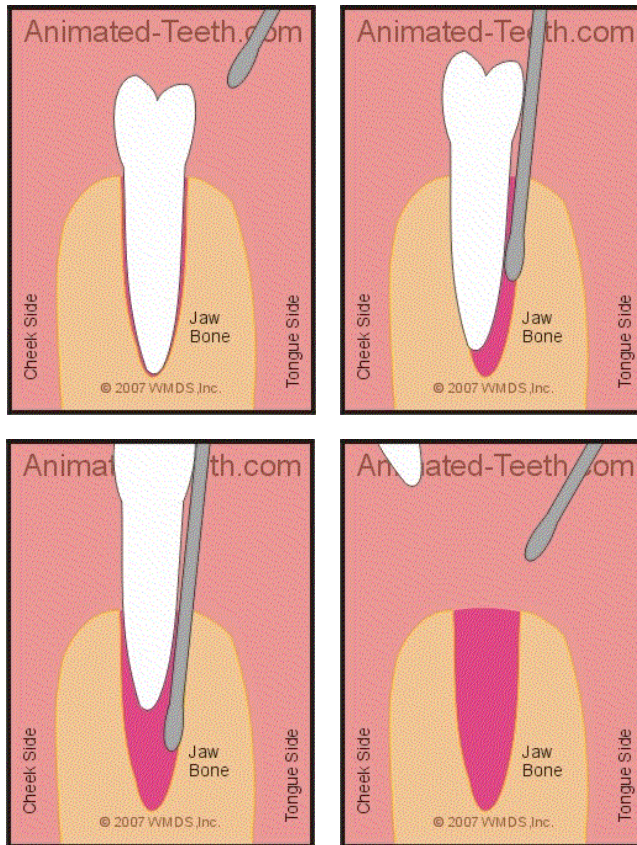


Figure 2.8 extraction with elevators

Source- https://www.animated-teeth.com/tooth_extractions/t5_extracting_teeth.htm(As seen on 25.09.17)

Your dentist will use these tools.

Dentists have a variety of tools they use to grasp and apply pressure to teeth. Some of them are pliers-like instruments called "extraction forceps." Others are specialized levers called "elevators."

Using an elevator to extract a tooth.

Dental Elevators

Elevator has a handle and then a specially designed "blade" or tip portion.

- The tip of an elevator is designed to be wedged into the ligament space between a tooth and its surrounding bone (as shown in figure 2.8).
- As the elevator is forced into and twisted around in this space, the tooth is rocked around and pressed against the walls of its socket. This helps to both expand the shape of the socket and separate the tooth from its ligament.
- As this work is continued, the tooth gradually becomes more and more mobile.

Literature review



Figure 2.9 extraction elevator

Source- <http://www.salvin.com/Complete-Set-of-5-Bayonet-Elevators-pluBAYONET-SET-OF-5.html>(As seen on 2.10.17)

- In some cases, the dentist may be able to completely remove the tooth just using their elevator. If not, they will choose a point where they feel they have accomplished as much as they can with it and will then switch to using extraction forceps to complete the job.

Dentist need different elevators according to tooth to be extracted, different type of available elevators are shown in figure 2.8



Figure 2.10 extraction elevators for different teeth

Source- <http://www.salvin.com/Complete-Set-of-5-Bayonet-Elevators-pluBAYONET-SET-OF-5.html>(As seen on 2.10.17)

Literature review

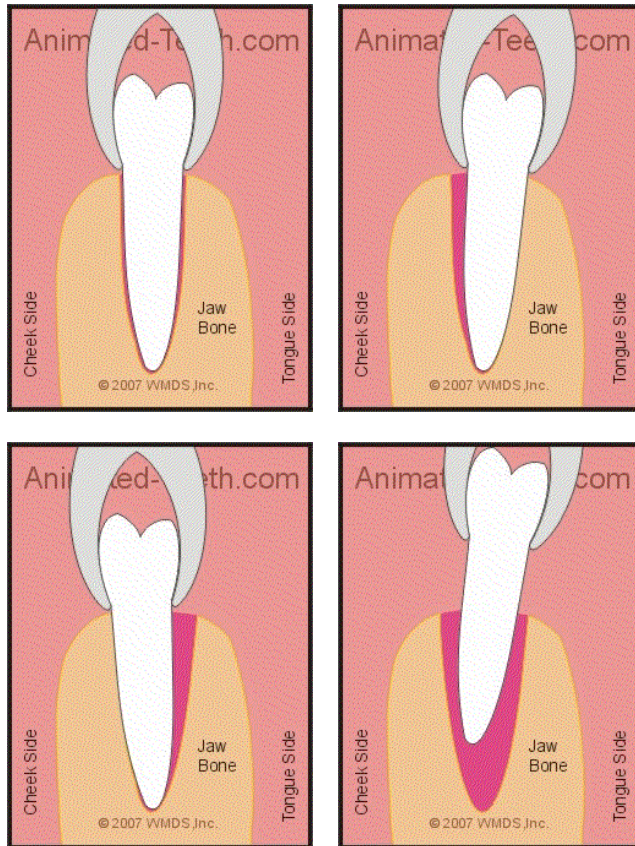


Figure 2.11 extraction with elevators

Source- https://www.animated-teeth.com/tooth_extractions/t5_extracting_teeth.htm(As seen on 25.09.17)

Dental forceps

dental forceps are used to grip the tooth so basically it is the plier-like thing which has gripper and handles and the dentist will have multiple forceps as a tip of the forceps are specifically design according to the tooth to be extracted by that forceps.

Also as visibility and accessibility are also criteria for forceps to design so accordingly forceps will be having tilt and turn to the tip of the forceps.

So specific type of tooth is extracted by the specific forceps.

- Dentist will grip tooth with forceps firmly and they will rock the tooth deliberately.
- As we know bone that surrounds the tooth is compressible, alveolar bone compresses and expands the bone cavity.
- With rocking motion and rotating the tooth Periodontal ligaments start breaking.
- At some point bone socket will get large enough and PDL are also breaks then dentist just pull the tooth vertically out for removal of tooth.

Literature review

Different forceps required for specific tooth extraction, every dentist will have set of forceps. Following forceps are observed in Dr. Shrungesh shah's hospital.

"Developed device should accommodate all tooth gripping tips or set of devices required to develop."



Figure 2.12 forceps for incisor and canines

Source- photographed at Dr. Shrungesh Shah' dental clinic



Figure 2.13 forceps for lower jaw premolars and molars

Source- photographed at Dr. Shrungesh Shah' dental clinic



Figure 2.14 forceps for upper jaw molars

Source- photographed at Dr. Shrungesh Shah' dental clinic

Literature review

Authors interpretation of Common problem occurs with traditional extraction method. This interpretation is based on a study done with books on dentistry and research paper reading.

- Buccal bone fracture
- Loss of alveolar bone which make immediate implant impossible
- Part of bone come out with tooth
- Root tip may fracture and stays within the bone socket, and removal of that fractures part become really difficult as visibility and accessibility is not much
- Pressure on tooth and bone leads to dental trauma to patient which gives post operative pain as there is excessive pressure applied while extraction
- Dentist hand gets fatigued if tooth is strongly anchored

Literature review

As the implant is getting common nowadays atraumatic extraction becomes the priority as any bone fracture or bone trauma lead to delay in implant placement. Because dentist has to wait till fractured bone gets connected, that will lead to 1-2 month delay in implant placement.

By the literature of Schwartz-Arad and Chausu the advantages of immediate versus delayed implant placement as follows

- Treatment time is reduced
- Amount of surgery is reduced
- Width and height of alveolar bone is preserved
- Ideal implant location can be achieved

“With the above-described process of traditional dental extraction, it is clear that there is a need for a more refined methodology which can offer atraumatic tooth extraction system.”

Literature review

Existing solution of tooth extraction

There have been a lot of efforts in this area for years. An extensive patent and market research was done to identify past efforts and research done in this area and devices. Following are some available atraumatic extraction technologies and products.

- Physics forceps
- Benex tooth extractors
- Periotome

Lets see the technique above extraction devices follows and what are the merits and demerits of the same.

Critical evaluation of those product will gives us design direction and require market placements of the device we are developing.

Lets look at the product one by one.....

Literature review

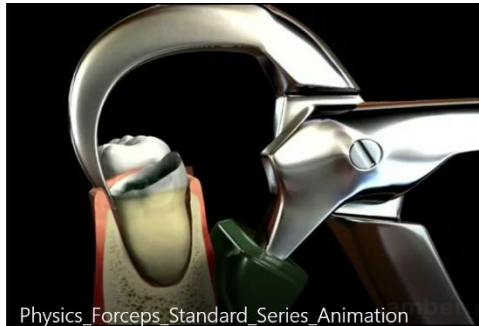


Figure 2.15a physics forceps locating
figure shows the placement of physic forceps, dumper is
rest on gum and beak is placed on the tooth

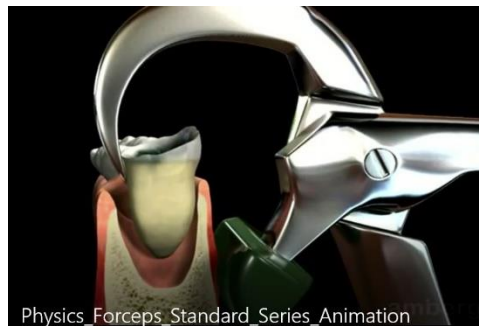


Figure 2.15b physics forceps locating
Taking support from dumper beak wedge out the tooth
from bone socket

Source- <https://www.youtube.com/watch?v=xot1p5V-K3s>(As
seen on 2.10.17)

Physics forceps

physics forceps golden dental solution have a beak
and bumper design which allows quick and efficient extraction of
the tooth. Physics forceps work on first-class lever principle taking
support from gum bone it is providing mechanical advantage to
the dentist,
After initial loosening normal forceps can be used to remove the
tooth.

As set of forceps physics forceps also come in set as shown in fig.
2.16



Figure 2.16 forceps for incisor and canines

Source- <https://goo.gl/VEDV7y>(As seen on 2.10.17)

Literature review

Authors interpretation on Advantages and disadvantages of physic forceps

Advantages	Disadvantages
• Efficient extraction (less than 4 minutes) • No need of clamping force • Advantage of leverage • Less fatigue to dentists hands	• A steep learning curve • Need to be very careful in mental foramen area • Difficult to apply on second and third molar • Deep Buccal undercut require special attention • Set costs between INR 50k-100k • Helps only loosening tooth

Table 2.1 Advantage and disadvantage on physics forceps

Literature review

Benex tooth extractor

benex system use direct pulling for removal of teeth, benex uses vertical tooth removal avoids socket expansion and minimize trauma and invasion. while this extractor useful for extracting single rooted teeth not multi rooted molar teeth.

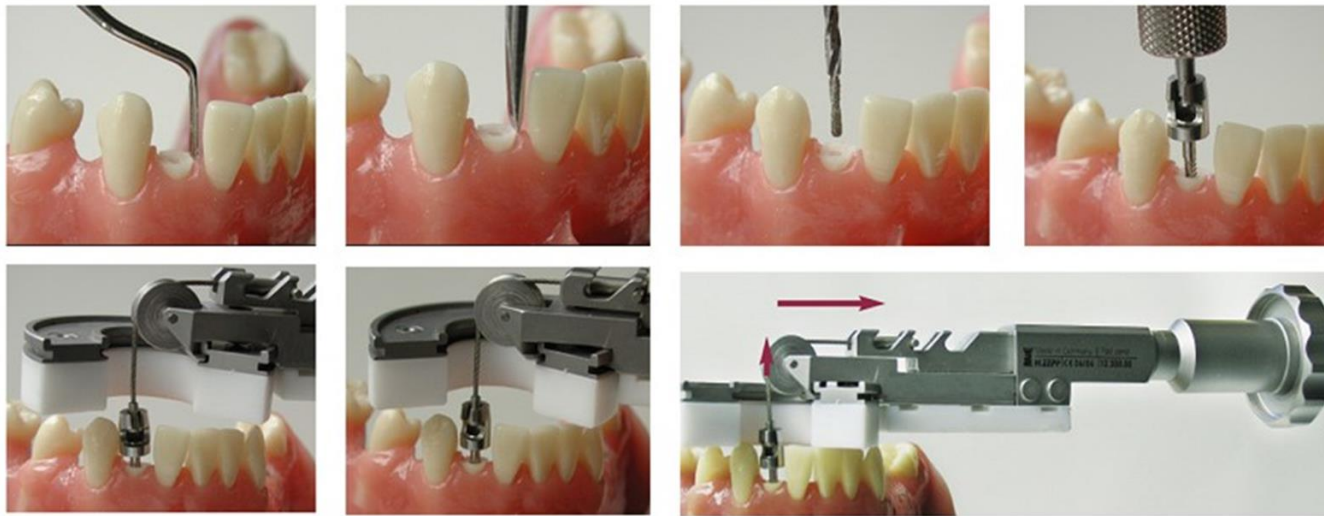


Figure 2.17 Procedure for use of benex extractor

Figure explains procedure to use benex extractor for tooth extraction it follows cutting PDL with luxators-drilling hole into tooth-anchoring screw into tooth-placing benex extractor on tooth –lifting tooth with rotating knob

Source- <https://goo.gl/VEDV7y>(As seen on 2.10.17)

Literature review

Authors interpretation on Advantages and disadvantages of benex extractor

Advantages	Disadvantages
• Reduced post-extraction bone restoration and preservation • Reduced trauma to alveolar bone • Improved success of intentional reimplantation/auto transplantation due to minimized trauma to PDL • Works for broken tooth	• Can not be used to extraction of molar • Procedure takes time • Set costs around INR 1.5 L

Table 2.2 Advantage and disadvantage on benex extractor

Literature review



Figure 2.19 periotome in use

Source- <https://goo.gl/7Q7RnY>(As seen on 5.10.17)



Figure 2.20 manual periotom

Source- <https://goo.gl/8pYnaV>(As seen on 5.10.17)

Periotome

periotome are blade like device which will cut down PDL ligament separating tooth and bone. Tip of periotome are gently inserted into the gums cutting ligaments and thicker periotome provides wedging advantage.

Flexible bade periotomes and powered periotome are also available now increasing the usability of the periotome



Figure 2.21 powerd periotoms

Source- <http://surgicalsolutionsusa.com/powertome-periotome/>(As seen on 5.10.17)

Literature review

Authors interpretation on Advantages and disadvantages of periotome

Advantages	Disadvantages
• Least traumatic to bone as no force applied • They come in increasing size for wedging action • Immediate implant is possible	• Require skill • Additional inventory (powered periotome) • Forceps might be required in last step • Very time consuming (30-45 minutes for tooth)

Table 2.3 Advantage and disadvantage of periotome

Clinical Immersion



Figure 3.1 Dr. Neeraj Rohida

Source- <https://goo.gl/Dxrv92>(As seen on 20.10.17)

Clinical Immersion

A dentists were consulted, extractions attained and lot of videos been watched regarding the tooth extraction to understand procedure and study the existing devices. Clinical immersion is important for such kind of device development. problem statement were stated on basis of that clinical immersion and existing literature.

Dentist meet

Dr. Neeraj Rohida

(PhD - Orthodontics & Dentofacial Orthopaedics, BDS Orthodontics)

- Atraumatic tooth extraction without any bone fracture and expansion of socket is really necessary for dentists and patient both.
- Stresses on hand especially wrist is more you will feel tired after extraction
- In case of molar and healthy tooth forces required to remove tooth is much higher, and even control pressure application make it more difficult.

Clinical Immersion

Dr. Neeraj Rohida

(PhD - Orthodontics & Dentofacial Orthopaedics, BDS Orthodontics)

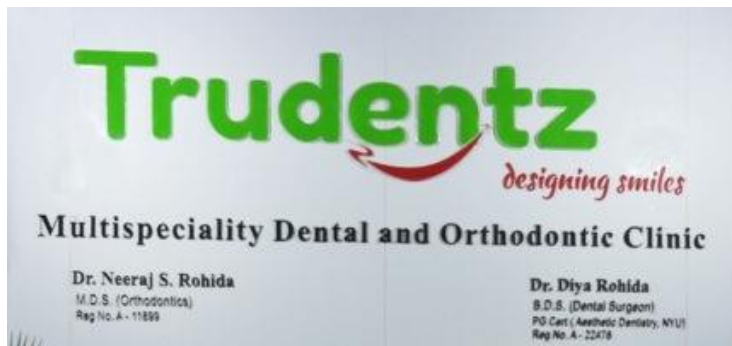


Figure 3.2 Dr. Neeraj Rohida's trudentz clinic

Source- <https://goo.gl/Hfd9p2>(As seen on 20.10.17)

- physics forceps is much quicker tool but it leads to fracture of alveolar bone and breaking of root in bone cavity .
- Some assistive tool reducing forces required for extraction is needed
- There are different forceps for different type of tooth, Beak orientation and gripping portion will be different
- With conventional forceps movement and forces are depend on skills of the dentist
- For removal of incisor ,canine will be no problem as forces required are less and accessibility is more but in premolar and molar it becomes difficult and time consuming also

Clinical Immersion

Dr. Shrungesh Shah



Figure 3.3 Dr. Shrungesh Shah
Source- photographed at Dr. Shrungesh Shah's dental clinic

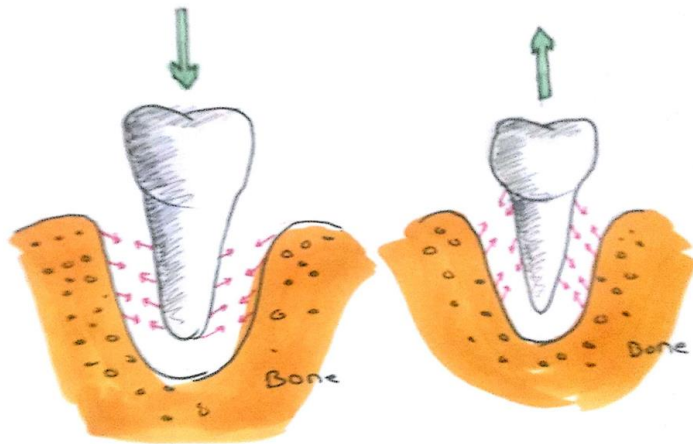
- Major difficulty faced by doctor while extracting the molar tooth as they are multi rooted tooth force required to removal of tooth is also higher.
- There are chances of tooth root fracture and root piece will remain inside the alvalore bone but it is non harming situation but when we have to make implant placement then that tooth root becomes the problem. And at that time removal of that piece becomes mandatory.
- Orientation of the tooth extraction is defined by the orientation of the roots in side alvalore bone.
- Device should be able to withstand the autoclave temperature and conditions.
- Device should be sturdy and simple to use which will provide accessibility to all the tooth.

Insights

Design insights were taken from dentists consultation, extraction observation and from study of existing literature on dental extraction

Insights which are critical to design the extraction tool and which can lead to different design direction are explained as follows.

- ***PDL is very weak in tension as majority of its fibers are adept to handling compression and not tension.***



Compressive load on PDL
While chewing

Tensile load on PDL
While extraction

Figure 3.4 PDL ligaments in compression and tension

Insights

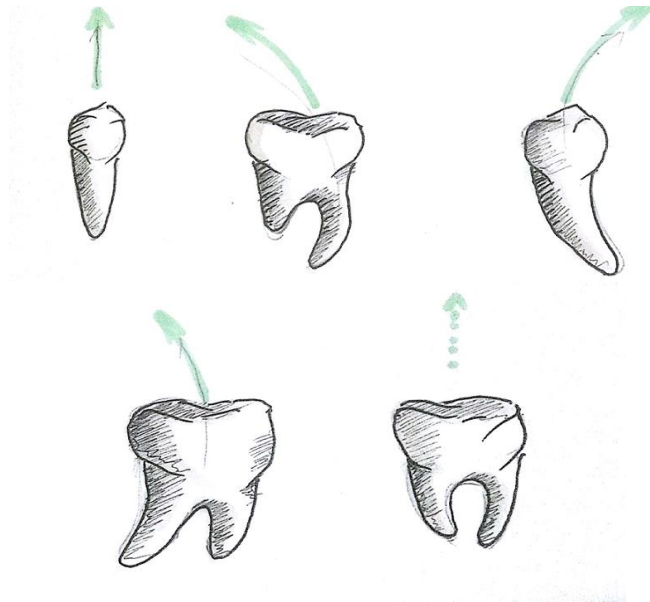
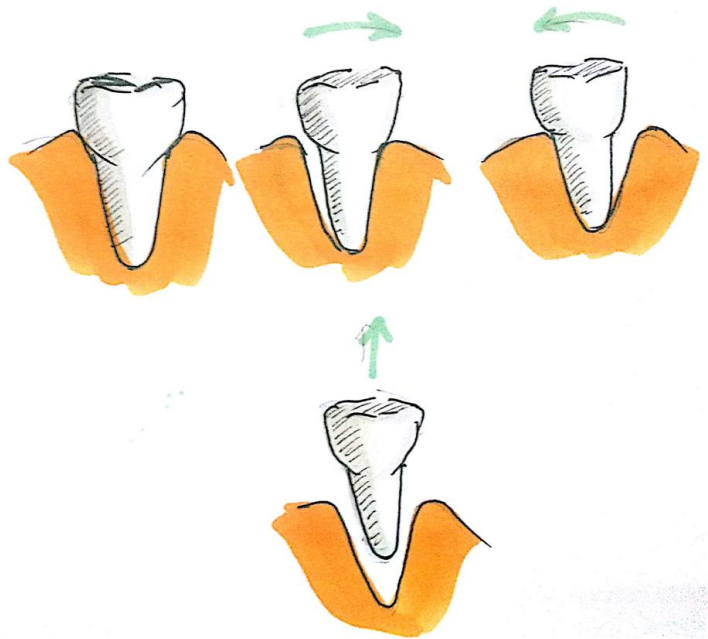


Figure 3.5 vector of extraction

- ***Minor force required to breakdown PDL and major contributor to resistance to tooth orientation and bone lock.***

Insights



- *Alveolar bone is porous and deformable.*

Figure 3.6 deformable alveolar bone

Insights

Insights

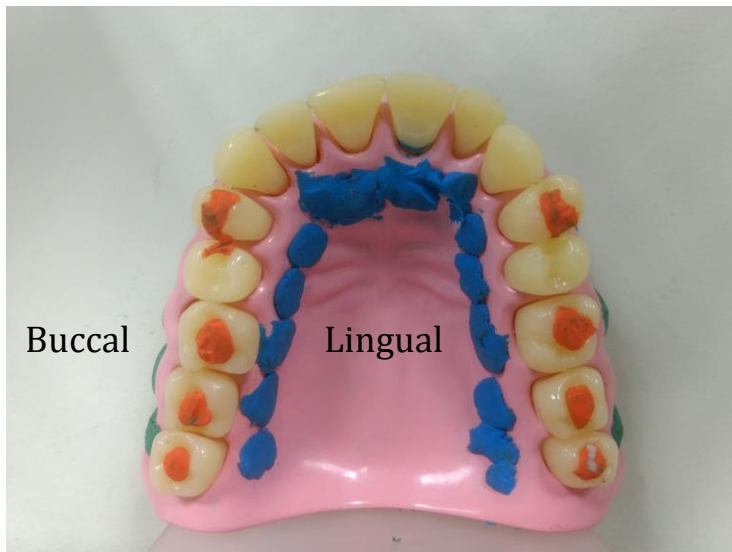


Figure 3.7 buccal and lingual direction

Source- [photograph of dental model](#)

- ***Bone thickness-difficult to extract in mesial or distal direction as adjacent teeth are present so it always extracted in buccal and lingual direction***

Bone thickness marking

- Thinner bone
- Relatively thicker bone



Figure 3.8 bone thickness marking

Source- [photograph of dental model](#)

Insights

- *Bone thickness-difficult to extract in mesial or distal direction as adjacent teeth are present so it always extracted in buccal and lingual direction*

● Teeth difficult to extract



Figure 3.9 marking of difficult to extract tooth
Source- [photograph of dental model](#)

Insights

- *Some teeth difficult to extract and reasons of difficulty .*

Difficult to extract tooth and reason for difficulties

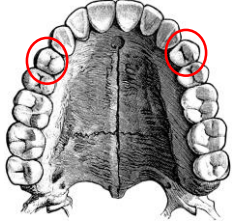
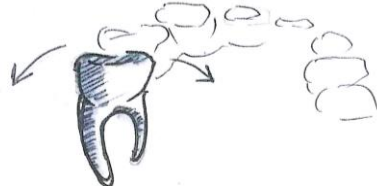
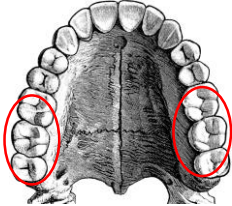
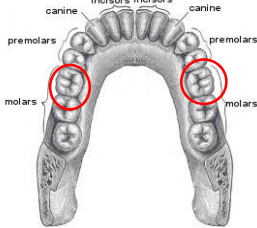
Type of tooth	Reason
Maxillary 1 st premolar 	Teeth have 2 slender roots in buccal and lingual direction 
Maxillary Molars 	Molar have 3 roots. 1 st molar have widely divergent root 
Mandibular 1 st molar 	2 roots in mesial and distal direction. Surrounded by Thickest bone 

Table 3.1 Difficult to extract tooth's

Objective

“Developing an easy to use tooth extraction device for dentist to minimize trauma”

*“Developing an easy to use tooth extraction device
for dentist to minimize trauma”*

Primary Need

- The device should be ergonomic and easy to use.
- As it is a class II device, it should be able to withstand autoclave temperatures.
- Amount of force require to extract tooth is quite high so device should assist dentist with mechanical or some kind of assistance
- The device when stored during operation should not allow the tip to touch any surface

“Developing an easy to use tooth extraction device for dentist to minimize trauma”

- **User related issues**
 - It should be easy to make tool ready for specific tooth extraction
- **Servicing issues**
 - Device should be capable of withstanding class II device sterilisation
- **Manufacturing issues**
 - Medical grade material to be used
 - The material should be easy to clean
- **Operating condition**
 - To be used in sterile conditions after sterilization
 - Devices should be placed properly on tray near the dentist within easy reach of at least the assistant

*“Developing an easy to use tooth extraction device
for dentist to minimize trauma”*

Functional requirements

- Autoclavable
- Device should be smart and easy to use
- Time required should be minimal
- Roots/root tip should not break while extraction
- No trauma to bone
- device should also work on broken crowns
- Easy extract multi rooted teeth and teeth with curved roots

Scope

The device will address to need of Atraumatic tooth extraction for multy rooted pre-molar and molars



In existing system there is high chances of bone fracture , gum trauma and root tip breakage.
Bone preservation becoming priority for implants

Feature not addressed

Device will not be focusing on extraction of singe rooted incisors and canons



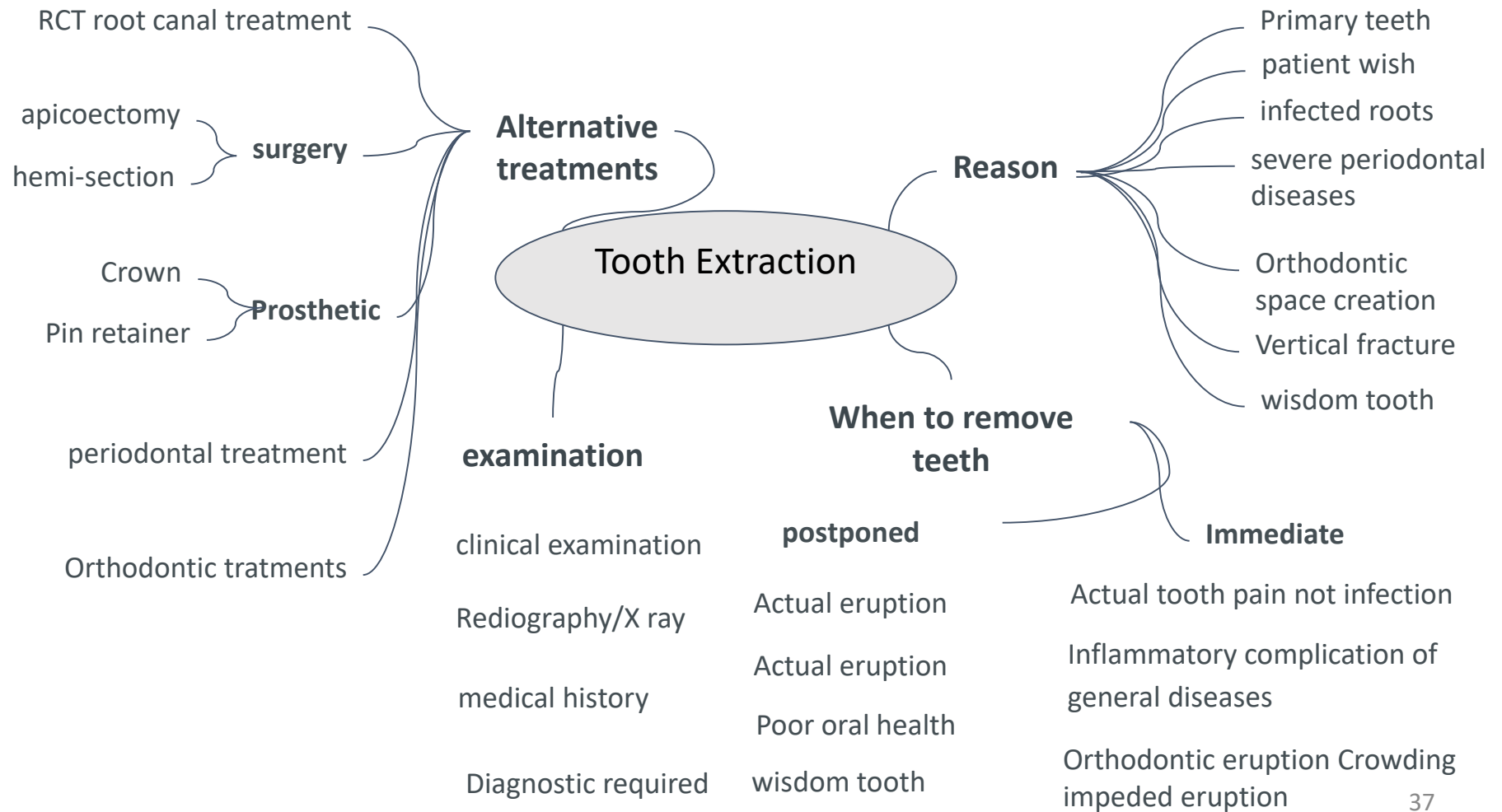
extraction of single rooted tooth are comparatively less traumatic and there are not many problems faced by dentist with existing solutions.

Device will also exclude wisdom tooth consideration

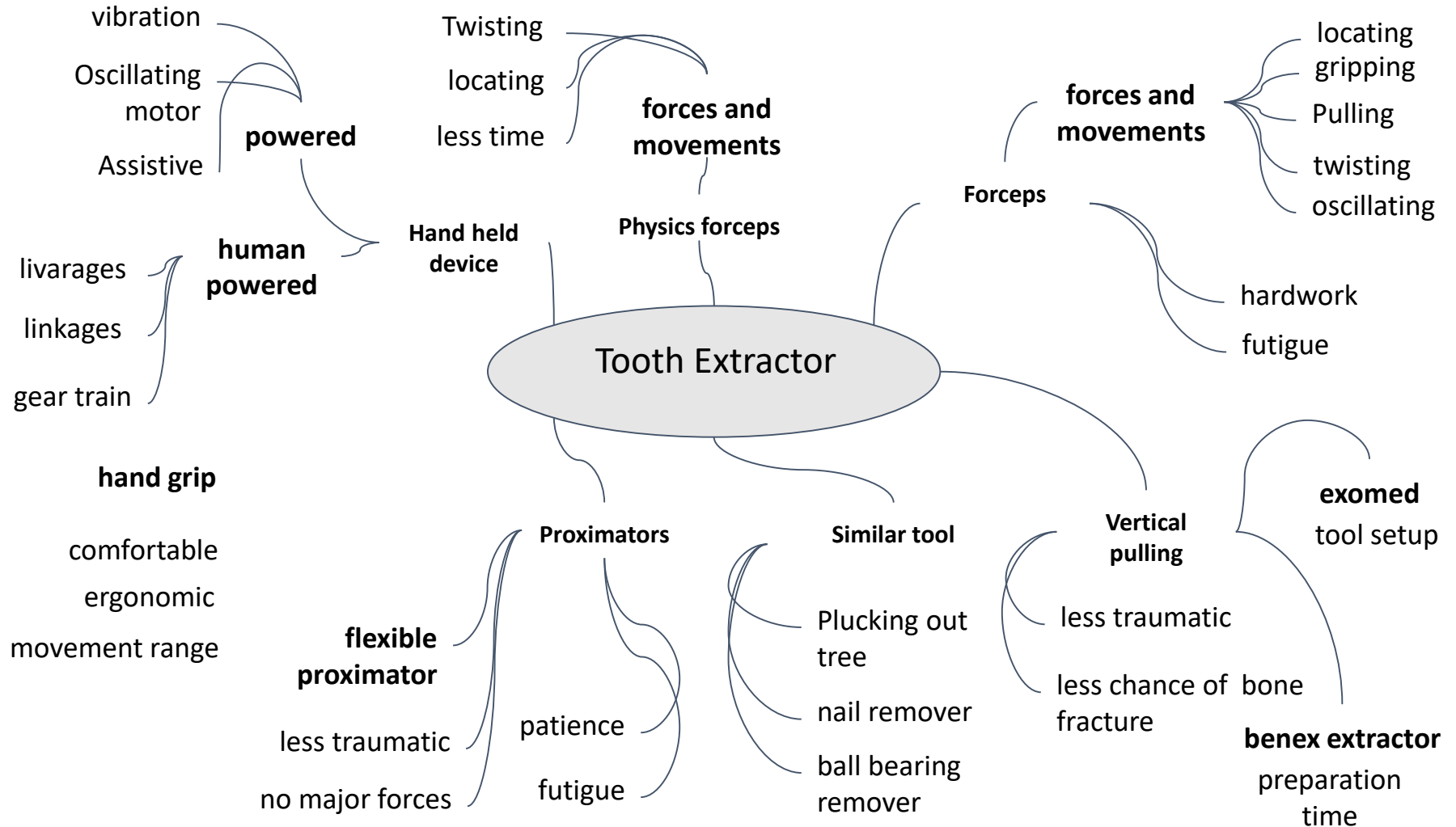


wide variation –totally different surgical operation required

Ideations



Ideations



Ideations

For Ideation, mind maps were prepared as shown in previous pages and brainstorming sessions were taken with the different peoples, designers, and non-designers, all ideas came on brainstorming session are noted down into the following table.

At the time of brainstorming, no idea was opposed or criticized.

Later ideas from brainstorming were critically analyzed with their feasibility advantages and disadvantages, and that comparison table is as follows.

Ideas came up in Brainstorming

Sr.No.	Technique	Advantages	Disadvantages
1	Pulling	Used by exomed and benex	Chance of fracture
2	Taping screw	No bone expansion	Process time
3	Vibration	Helps to loosen up	
4	Cut PDL cutter	periotoms	Time consuming
5	Burn PDL		localization
6	squeeze bone		Bone damage
7	Make bone grow		Time consuming

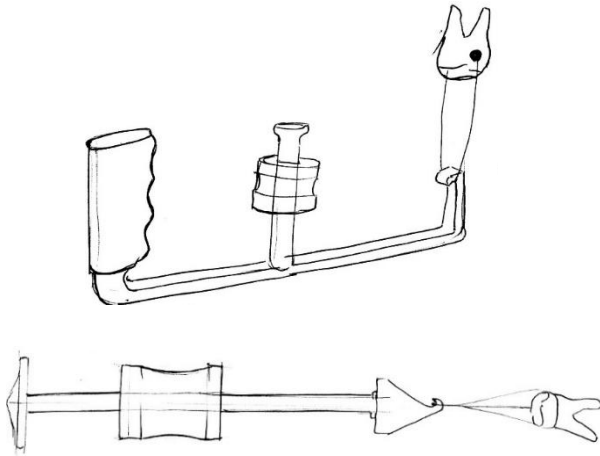
Ideas came up in Brainstorming

Sr.No.	Technique	Advantages	Disadvantages
8	Water jet/Air jet		localization
9	Micro robot breaking PDL		Technology, space
10	fatigue		
11	Micro explosion		Bone tissue damage
12	sectioning	Used for molars	Time consuming
13	Braces and chewing action		Time consuming
14	Ultrasonic		

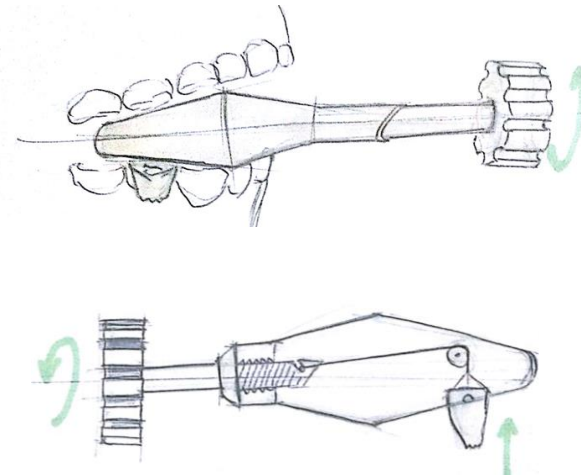
Table 7.1 brainstorming ideas

Ideations

Based on brainstorming ideas some ideation have done. In which following different directional ideas where created.

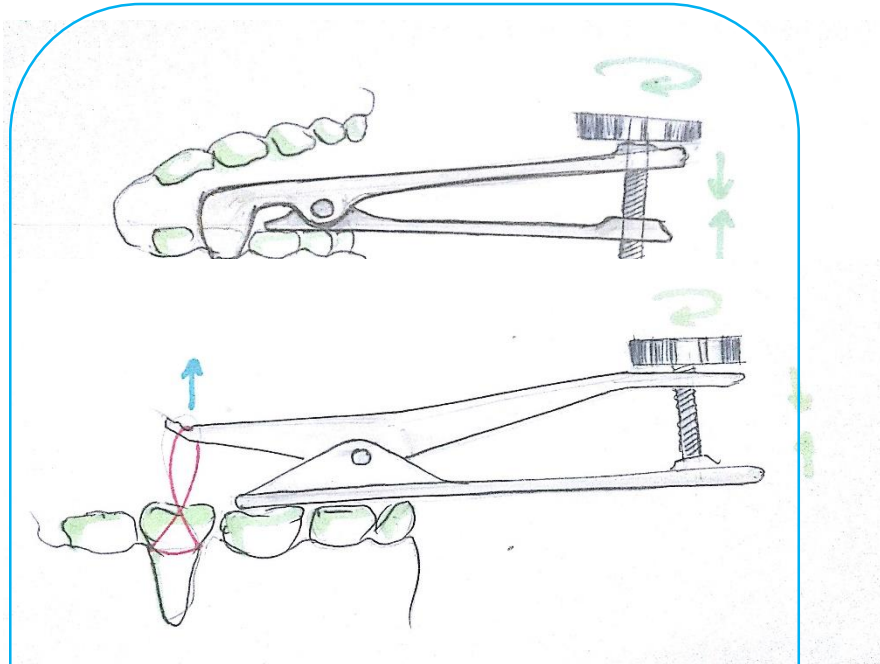


In this manual hammer kind of thing was thought which provide jerks to the tooth resulting loosening of tooth.

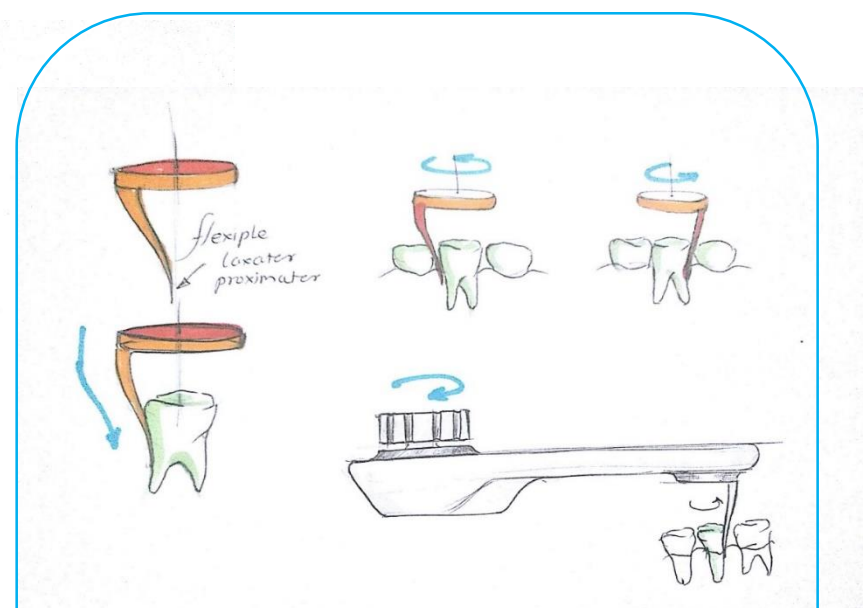


Taking inspiration from gum bite, the device can be like gum bite which will locate on the tooth to be extracted and rotating knob can lift up the tooth like as crane.

Ideations

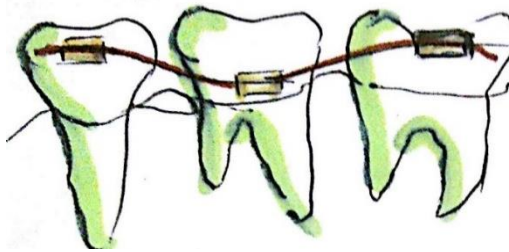


Taking support from the rest of tooth, the decayed tooth can be extracted with a screw-like mechanical assistive system which will reduce dentist effort to the maximum extent.

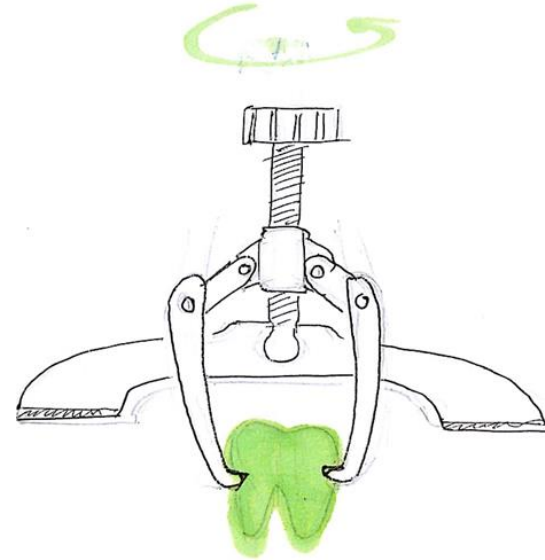


Device can have flexible blade which rotates around the tooth cutting the periodontal ligament and loosens up the tooth.

Ideations

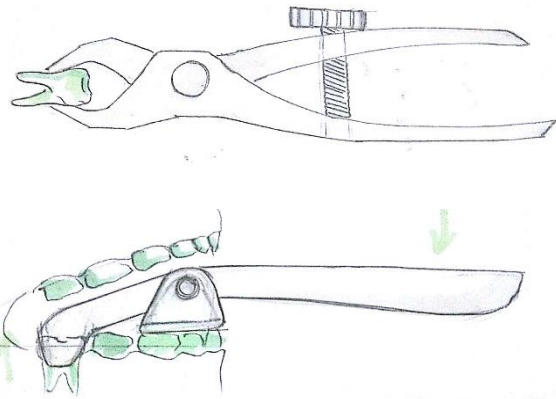


As dental braces used to move tooth in bone that same principle can be used to remove tooth. Time required to extract will be large in this case.

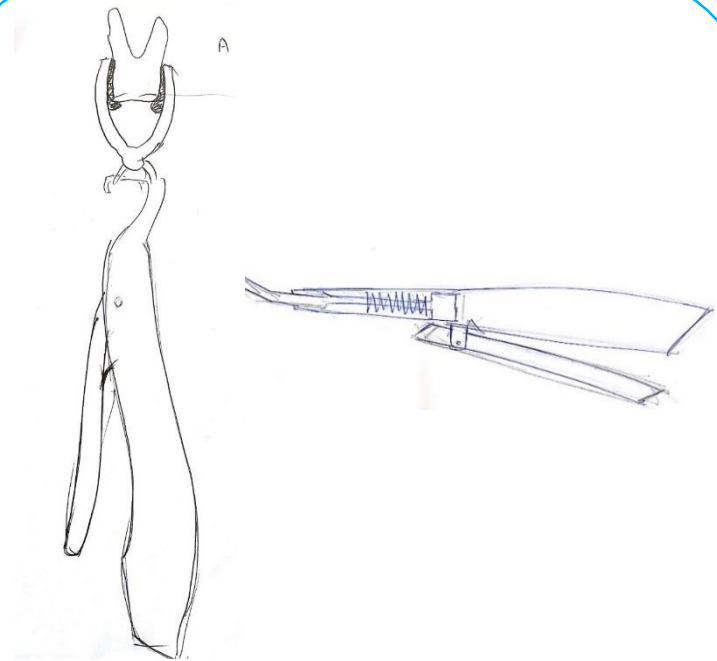


Inspired from bearing remover tooth can be hanged or clamped, and can be lifted with treading

Ideations



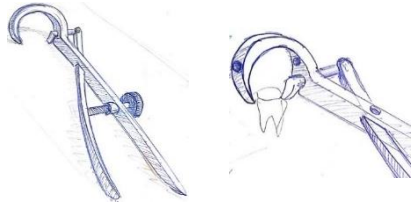
Locking plier which take leverage from tooth and elevate the tooth



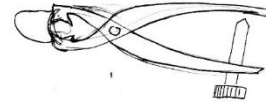
Vibrator which works on compressing spring can generate jerks which will loosen up the tooth

Ideations

With different tooth extraction ideas different gripping mechanisms are also been thought of, As gripping tooth is critical task in tooth extraction procedure.

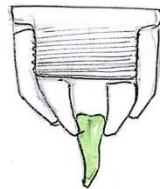


Offset plier which will provide maximum visibility

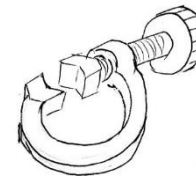


Locking plier which can lock and stay in gripping position

Tooth grippers



Drill chuck system which will grip on tooth with rotation of knob



C clamp or F clamp which grip the tooth with rotation on handle

Concepts

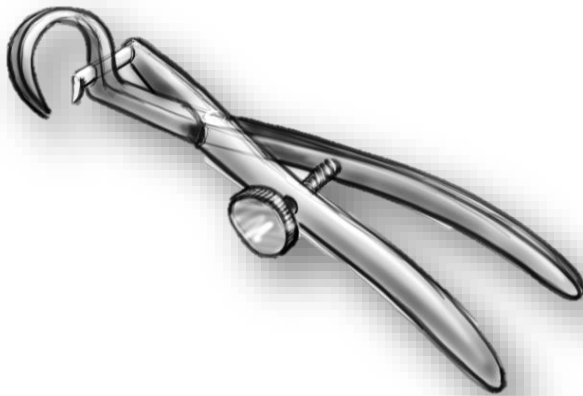
With different idea clusters some concepts are been developed where one specific idea is taken forward or combination of multiple ideas are combined.

Concept 1

This concept combines the idea of offset plier for maximum visibility and vibrator for loosening us the tooth .

1

Gripper



2

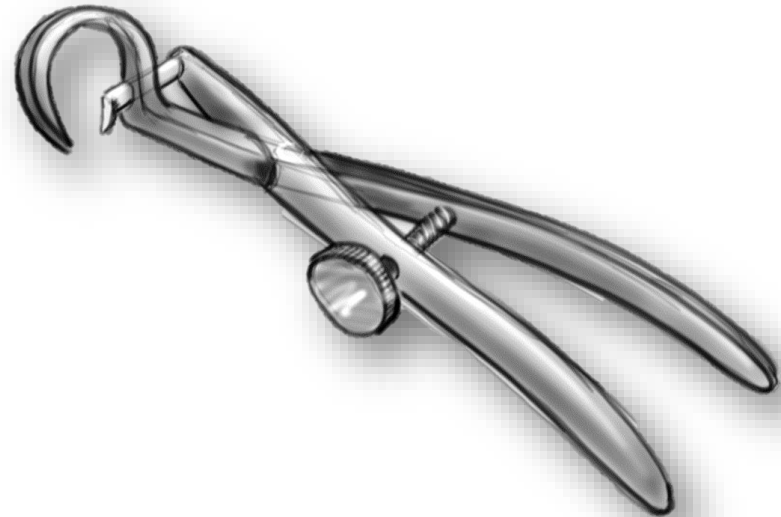
Vibrator



Concepts

Gripper

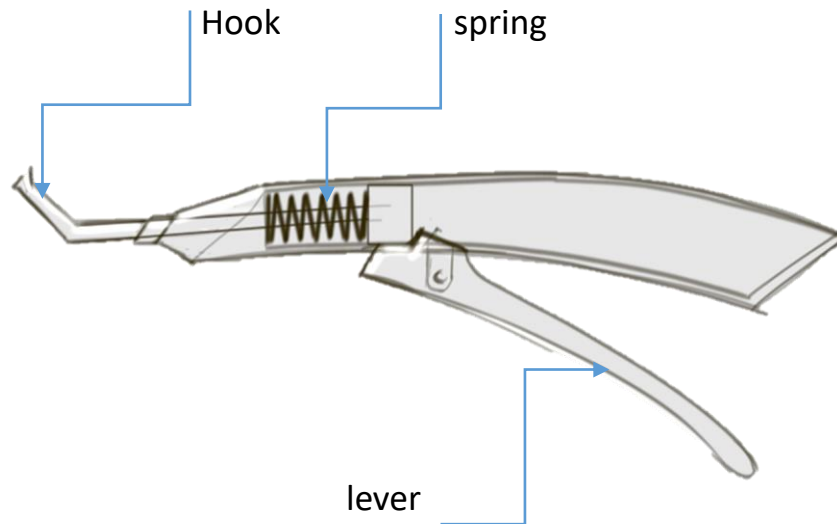
Gripper will grip the tooth in the offset manner so that visibility and accessibility of the tooth are maximum to the dentist



Concepts

Vibrator

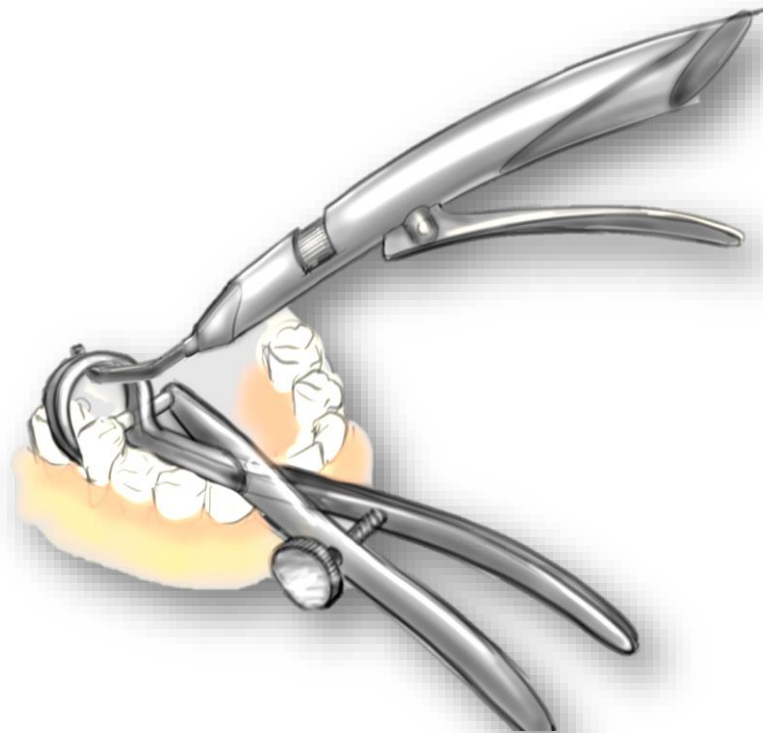
As liver of liberator gets pulled spring inside gets compressed and it progresses at time it sleeps and provide hammering jerk to the tip of the tool.



Concepts

Working

Vibrator tool tip gets hooked to the loop of offset plier and as handle pulled it will provide jerks to the plier and subsequently to the tooth, it will loosen up the tooth and tooth will be extracted.



Concepts

Concept 2

In this concept adhesive clips are used for gripping the tooth. Gripping part is taken care by the adhesives. For lifting part of extraction mechanical advantage of leverage and screw mechanism is used. Screw helps to gives more controlled and effort less lift.

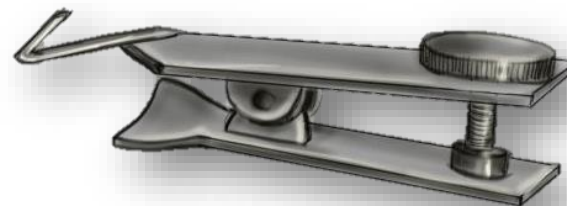
1

Adhesive clip



2

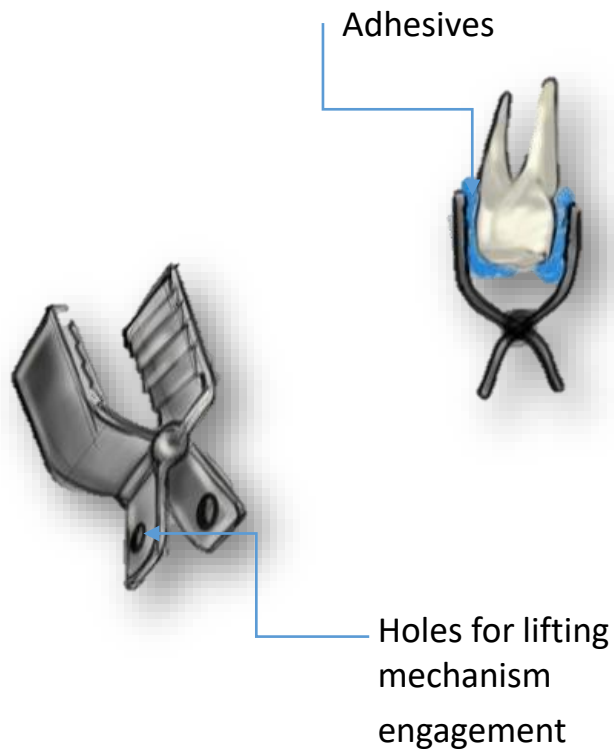
Lifter



Concepts

Adhesive clip

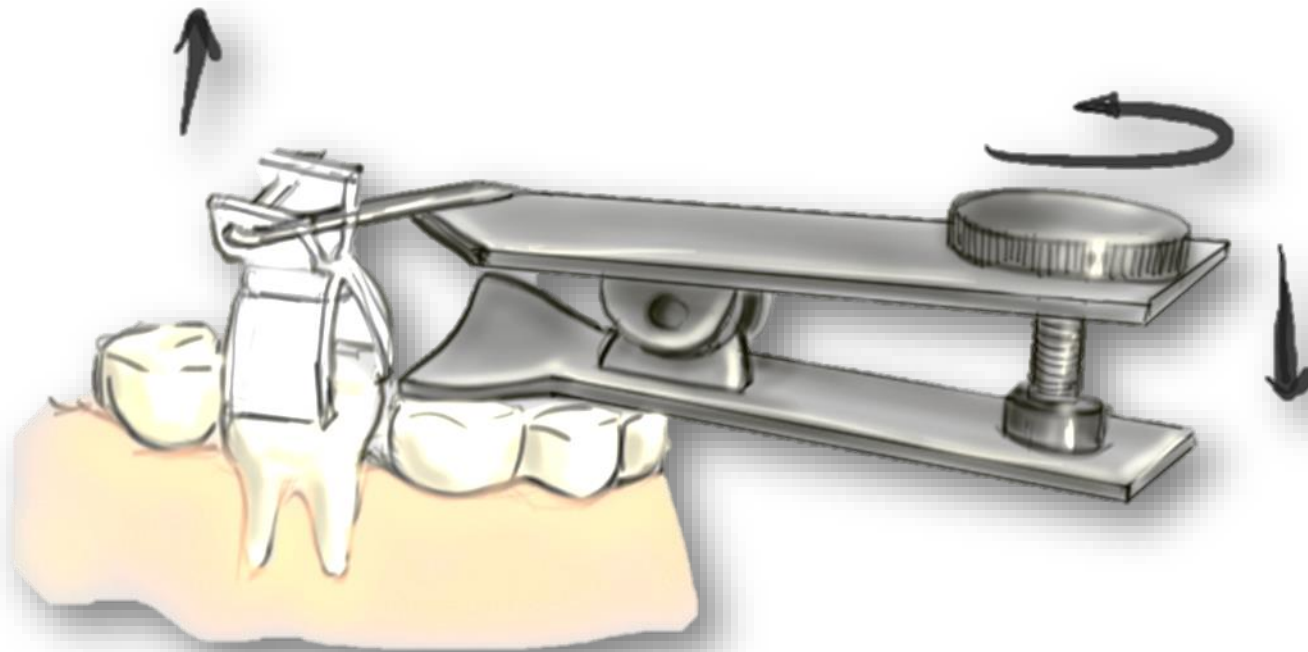
Clip will have quick setting biocompatible glue which sets in UV lights. Some adhesives are already in use for ornamentation of tooth. Clip will have readily available holes which could be used for engaging the lifting mechanism.



Concepts

Working

Lifter have front portion which will get attached to clip, lifter will take support from healthy tooth. Lifter have mechanical advantage of screw so it will generate powerful lift which pull out tooth from bone socket.



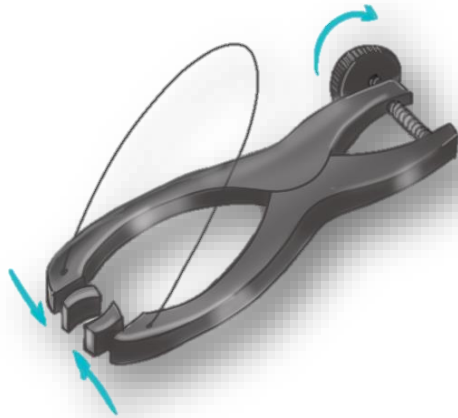
Concepts

Concept 3

This concept is inspired by the crane system where gripping plier clamps the tooth which is to be extracted and has thread attached to it which could be pulled by crane.

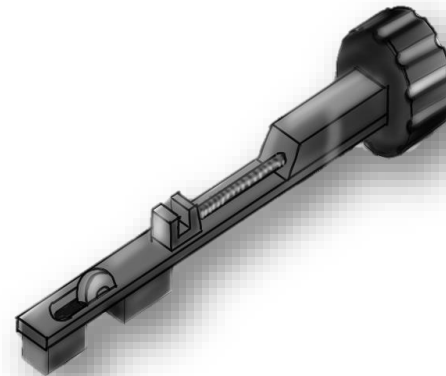
1

Locking plier



2

Crane



Concepts

Locking plier

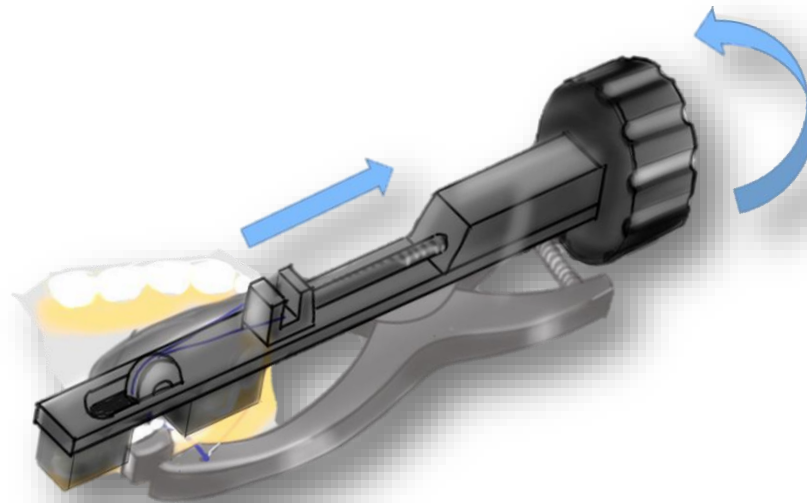
Locking plier is to be located and tighten with screw so plier will grip the tooth, this assistive gripping provide the ease and comfort to Dentists for further procedure. This plier will also provide flexible member like thread which will help for lifting the teeth.



Concepts

Working

String attached to plier have to insert in the crane hook, crane will rest on healthy tooth and as knob rotate it will pull the thread lifting the plier and tooth.



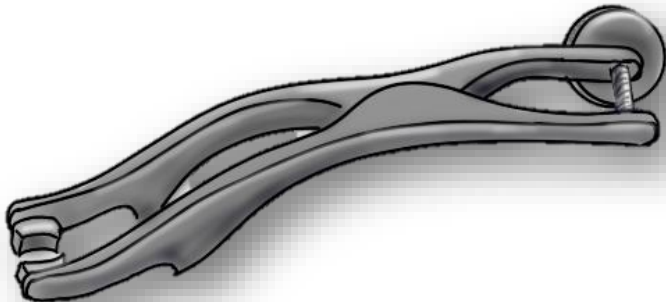
Concepts

Concept 4

This concept is basically alternate version of the previous concept where lifting mechanism is changed into supporting bridge which can take support from healthy tooth and provide leverage advantage.

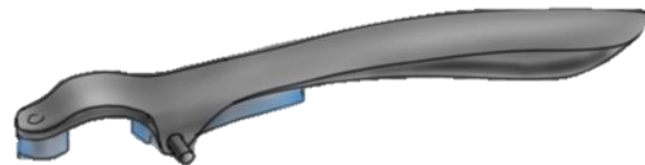
1

Locking plier



2

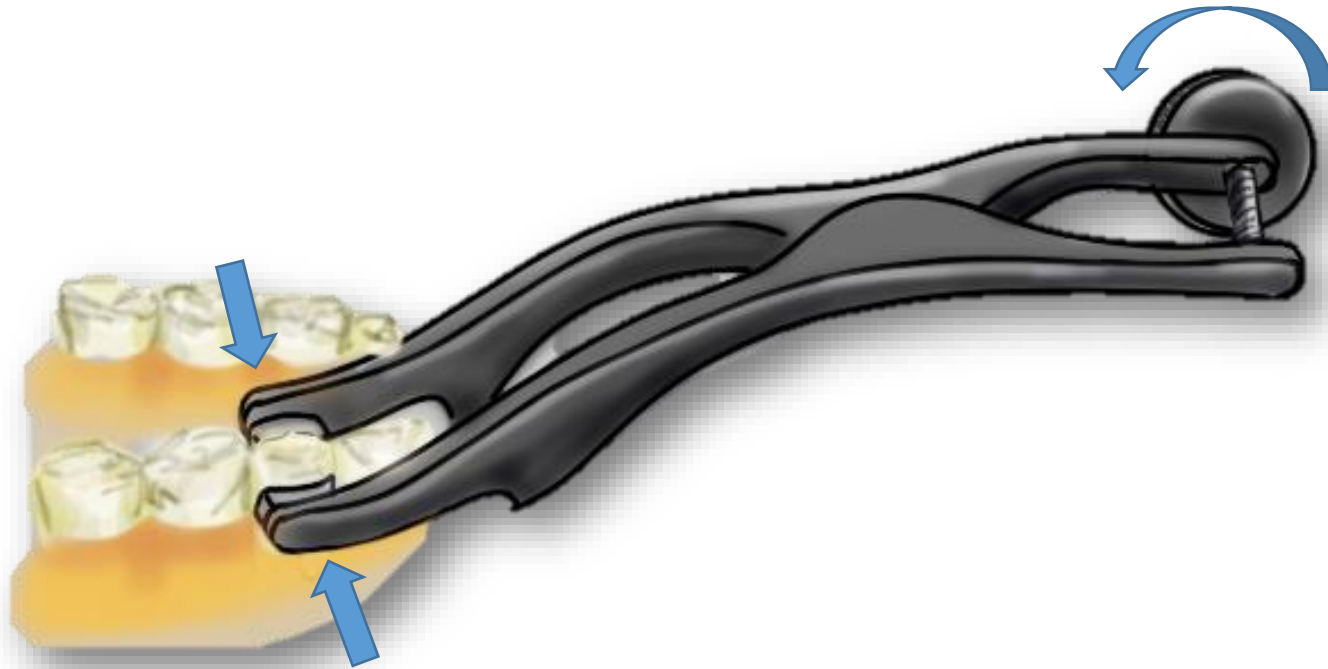
Support bridge



Concepts

Locking plier

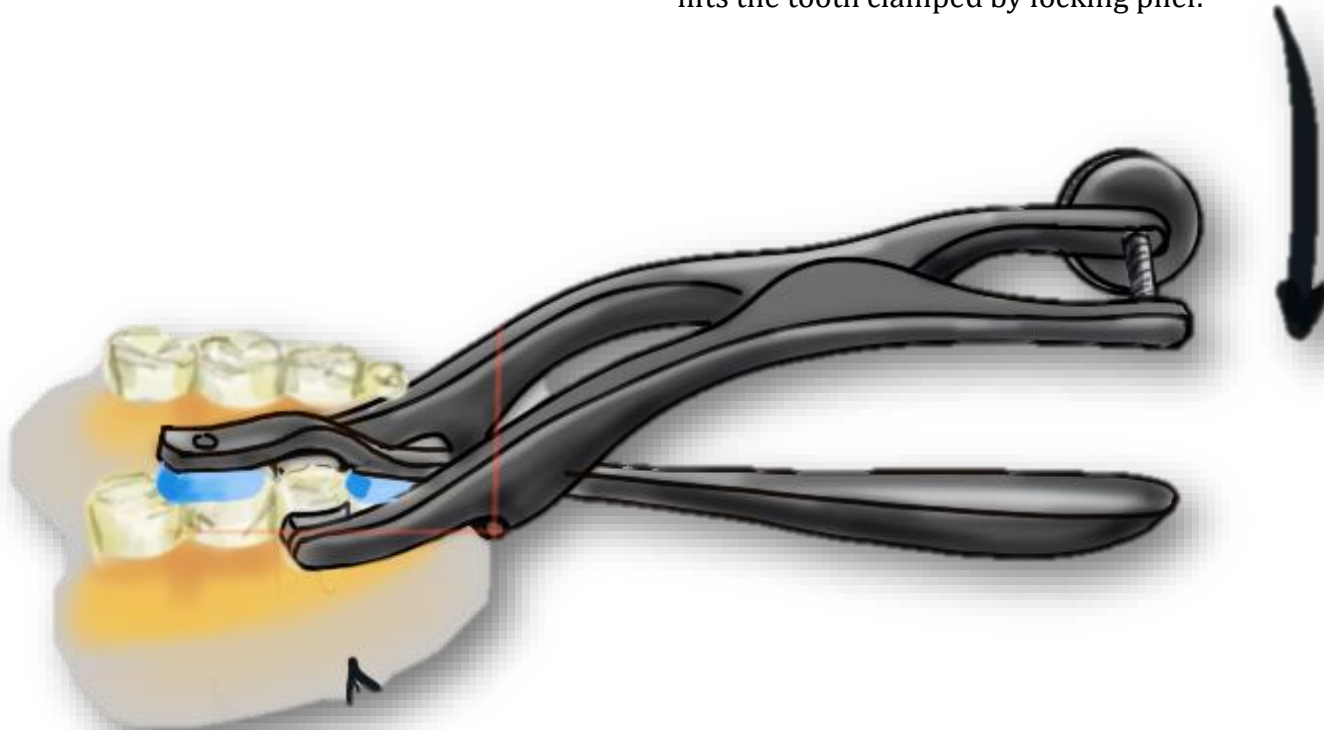
Locking plier is to be located and tighten with screw so plier will grip the tooth, this assistive gripping provide the ease and comfort to Dentists for further procedure. This plier will also have pivot locator, which will form hinge when support bridge will come in picture.



Concepts

Working

Support bridge to be inserted and located on tooth as pivot gets placed perfectly on plier, support bridge and locking plier now forms an another plier which take support from healthy tooth and lifts the tooth clamped by locking plier.



Concept Evaluation



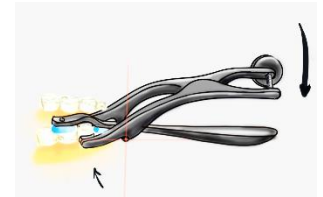
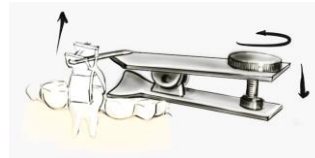
Figure 9.1 Dr. Shrungesh Shah

Source- photographed at Dr. Shrungesh Shah's dental clinic

Remarks of Dr. Shrungesh Shah on concept mockup

- Vibration are good for tooth cap removal but in tooth extraction vibration might not work satisfactorily as PDL are flexible and sustain in vibrations.
- Mechanical advantage will allows them to extract tooth vertically which will be good for bone preservation, which is not possible in existing systems because of its difficult too generate that force by plier.
- Including light and vibration in device will be good idea but it should not affect the robustness of the product .
- Available tooth adhesives are not that strong that they will sustain forces apply for extraction

Concept Evaluation



	Concept 1	Concept 2	Concept 3	Concept 4
Compatibility to all tooth	More favorable	More favorable	More favorable	More favorable
Visibility	More favorable	Favorable	More favorable	More favorable
Accessibility	More favorable	Favorable	More favorable	More favorable
Effort required	favorable	More favorable	More favorable	More favorable
Setup time	favorable	Less favorable	Less favorable	favorable
Disturbance to healthy tooth	Favorable	favorable	Less favorable	favorable
Learning curve	favorable	Less favorable	favorable	favorable

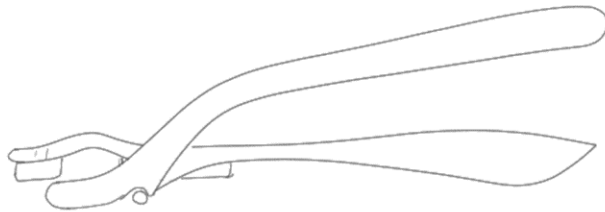
Concept Evaluation

Concept Evaluation is done for above 4 concepts keeping evaluation criteria as compatibility of device for all the tooth, visibility ,accessibility, effort required from doctor for extraction, any kind of disturbance to the healthy tooth or tissue and learning curve of dentist to use that device.

Those evaluation criteria's are discussed with doctors for verification. Mockup model of the all concepts are shown to the doctor and above evaluation criteria are discussed for evaluation of the respective concepts.

As evaluation can't be quantitative in this stage so qualitatively concepts are evaluated, giving remarks less favorable ,favorable and more favorable. Subsequently one concept is get selected with this process, that is concept 4.

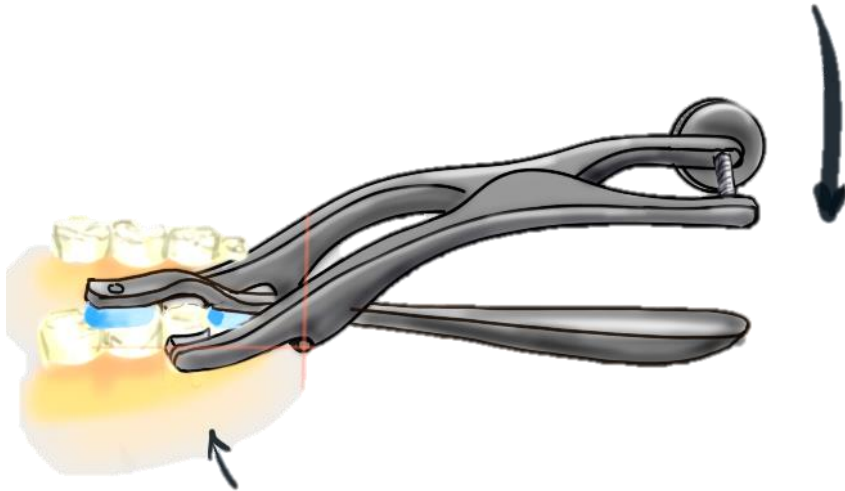
Concept 4 is selected for further development of the device.



Final concept

Concept refinement

From all the concepts this following concept come up to be more appropriate one. Chosen concept have following advantages which makes it leading on amongst all the concepts.



- Assistive gripping means
- Use of screw for gradual and controlled grip.
- Maximum visibility and associability as supporting bridge come later In process.
- Leverage advantage which will reduce the effort required by the doctor and still have resistance feedback to doctors hand

With this advantages this concept is taken further.

This concept is been worked out for gripping part of tooth and to accommodate every scenario that might come in tooth extraction.

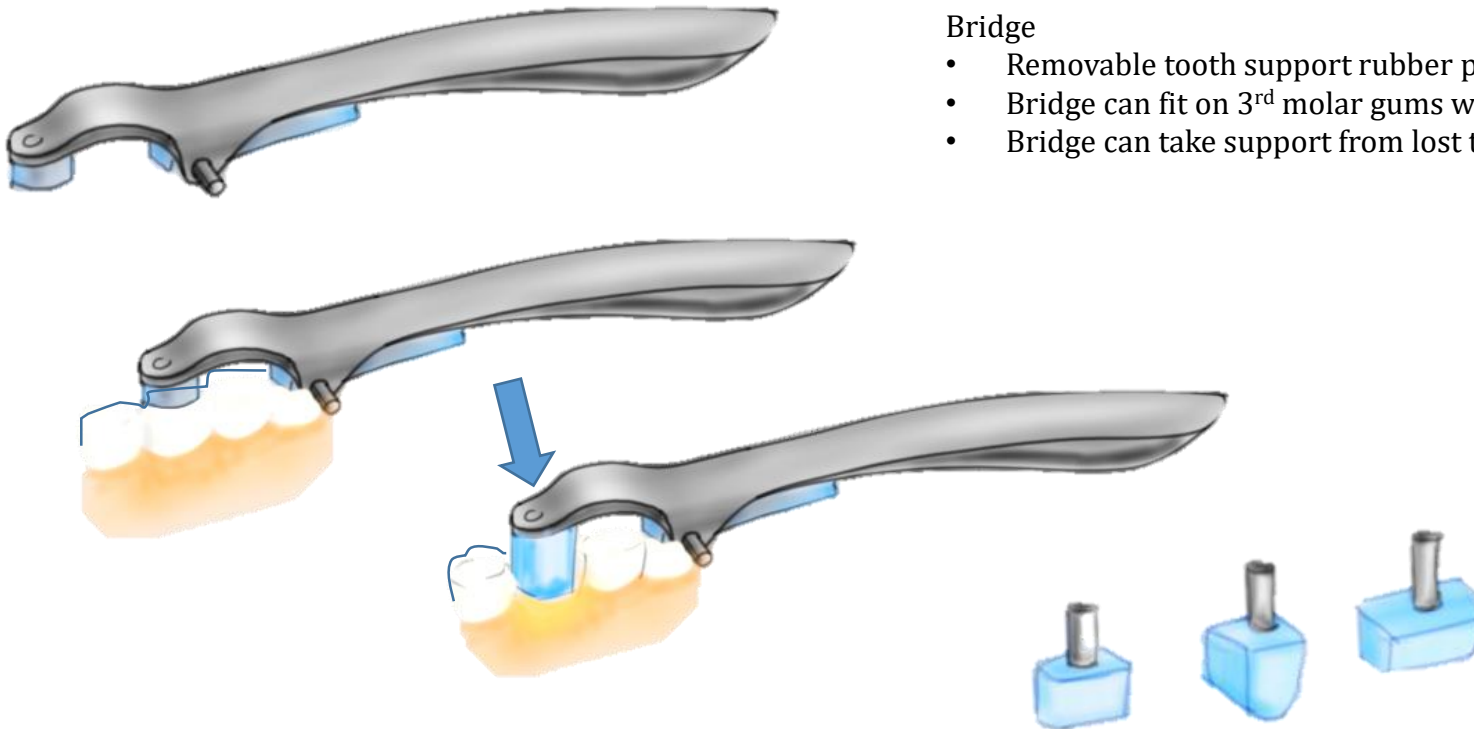
Concept refinement

Refinement of supporting bridge

To accommodate every possible scenario which could come in tooth extraction supporting bridge have replaceable rubber supports.

Bridge

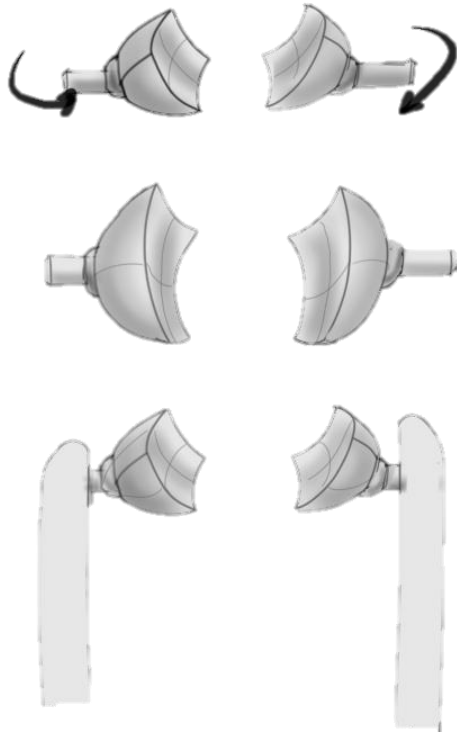
- Removable tooth support rubber pads
- Bridge can fit on 3rd molar gums with attachments
- Bridge can take support from lost tooth gums



Concept refinement

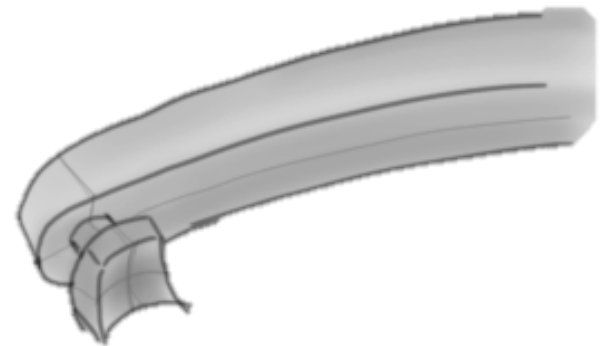
Refinement of grippers

Currently dentist will have different forceps for different tooth as gripping edge differs for each tooth. To make this device capable that one device could be used to extract each tooth by just replacing the gripping jaw.



Tooth gripper

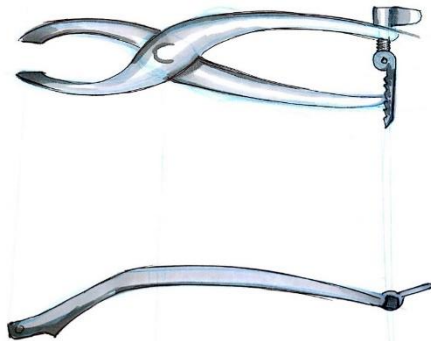
- Replicable grippers
- Different grippers for different tooth according to their profile
- One pair of gripper having two gripping size



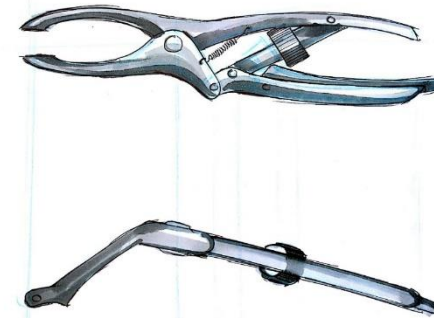
Concept refinement

Exploration of gripper mechanism

Gripping tooth is one of the major and critical task in tooth extraction process. This assistive gripping will ease out the further process for the dentists. Gripping is critical task where gripping progressively with doctors feedback is necessary. Some of the ideas for gripping is though which can work for selected concepts.

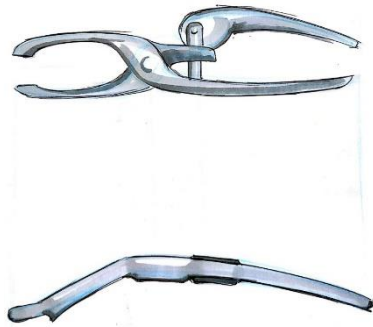


Ratchet

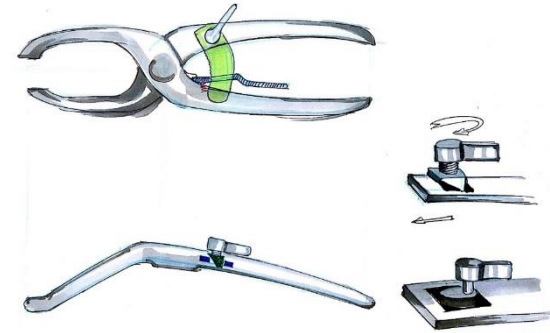


Quick clamps

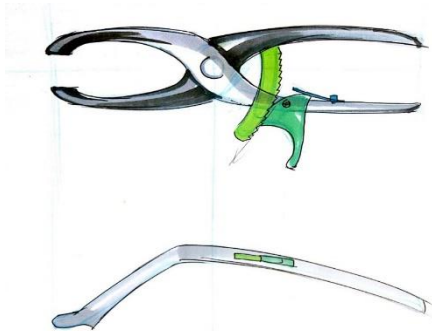
Concept refinement



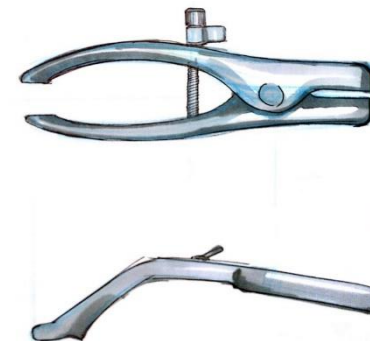
Face cam



Quick clamps



Ratchet

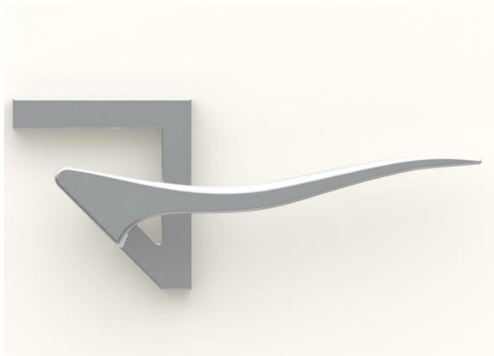


Screw

Concept Refinement

Mood board

Edge - curve - transforming - transition



<http://huaban.com/pins/1653921941/>(As seen on 20.12.17)
<http://www.justeasy.cn/news/2580.html/>(As seen on 20.12.17)

Concept Refinement

Mood board

Roundish - volume - radii - bulky



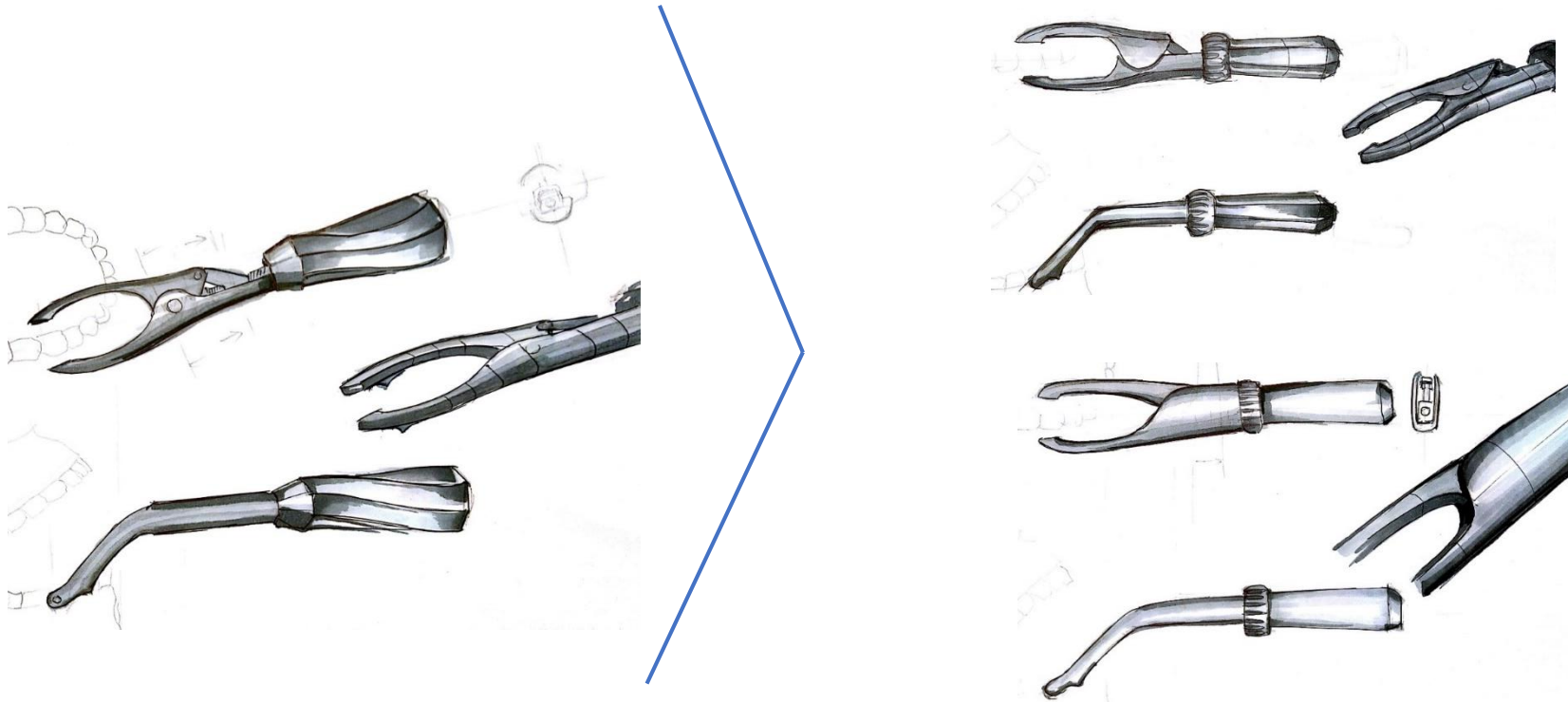
<http://ironmongeryuk.com/fortessa-fdeava-sc-avant-garde-lever-on-rose/>(As seen on 20.12.17)

<https://www.hu-friedy.com/surgical/forceps/extraction/99c-kells-forceps/>(As seen on 20.12.17)

Concept Refinement

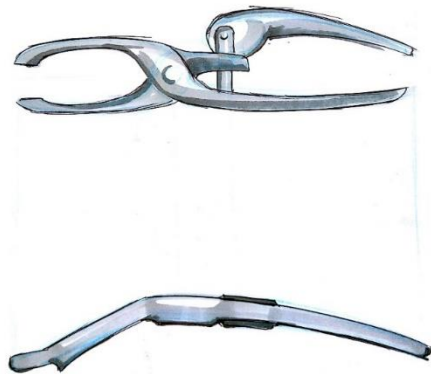
Form explorations

Getting inspired by mood board some of formal exploration with respect to mechanism are done.



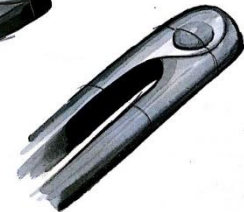
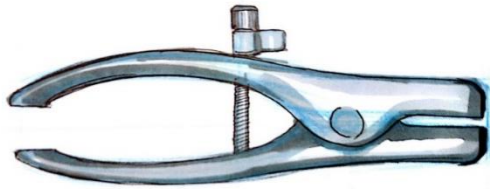
Concept Refinement

Form explorations



Concept Refinement

Form explorations



Concept Refinement

Form explorations

Form models of different mechanism are made in thermocoal to test the usability and user interactions.

Those mockups were taken to Dentist for discussion about user interaction and extraction procedure for each mechanism. each mockups were discussed with user interaction points and shortlisted workable approach and final direction is also selected with discussion with dentist.

Mockup with screw mechanism is selected.



Figure 10.1 form exploration for different gripping mechanism

Source- photographed

Concept Refinement

Form explorations

As screw mechanism approach was selected to take further, Some exploratory form options are prepared with same mechanism.

Prepared form mockups are also discussed with guide and dentists for there opinion.

Different form models were studied with different corner treatments like fillet, corner, chamfer etc.



Figure 10.2 form exploration of gripping mechanism

Source- photographed

Concept Refinement

Form explorations

Selected foam Models are made with consideration like gripping, finger position, wrist movement and all and larger efforts gone into finding the perfect pivot point which will be appropriate for this system.

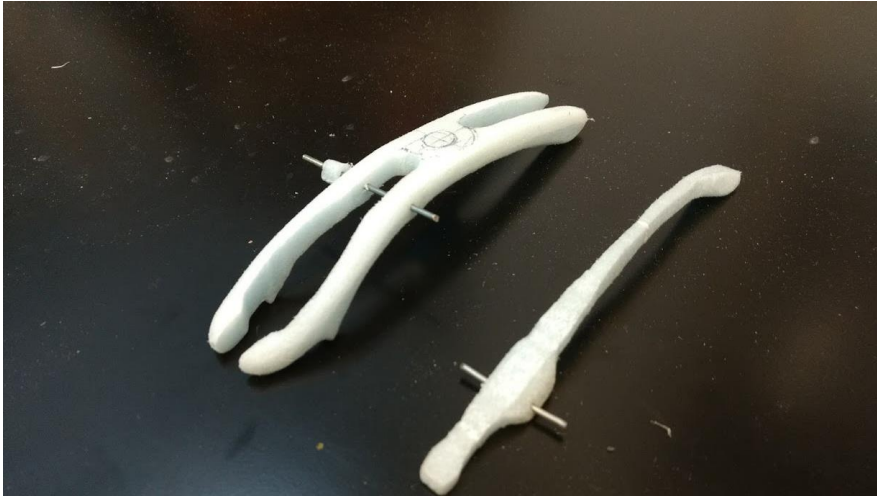


Figure 10.3 selected form mockup

Source- photographed

Final Concept

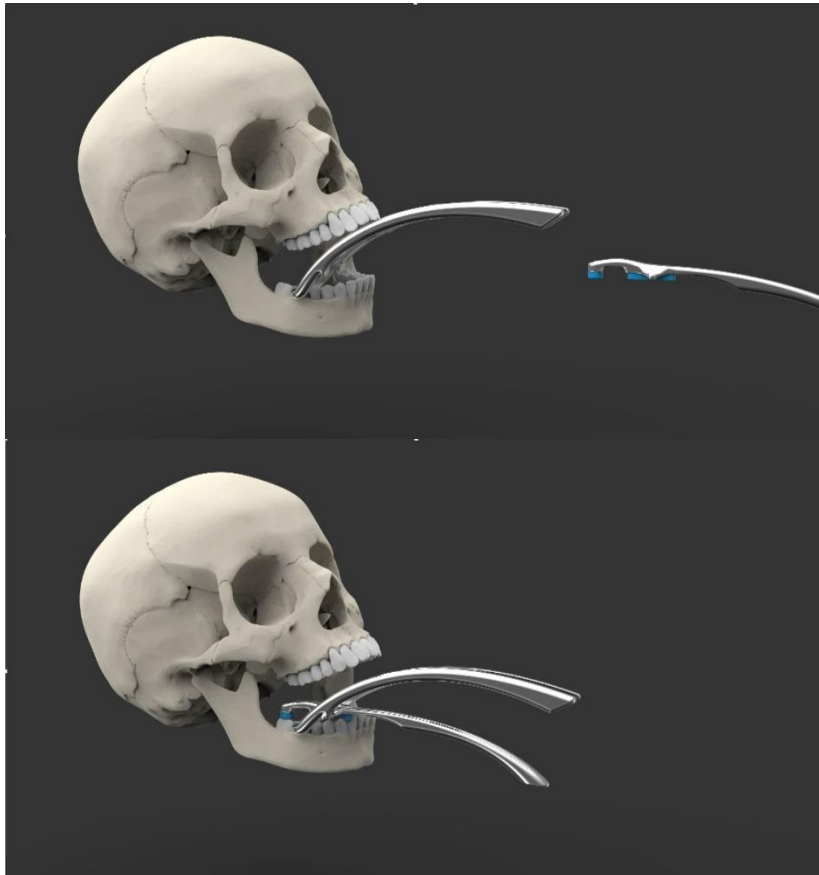


Final Concept

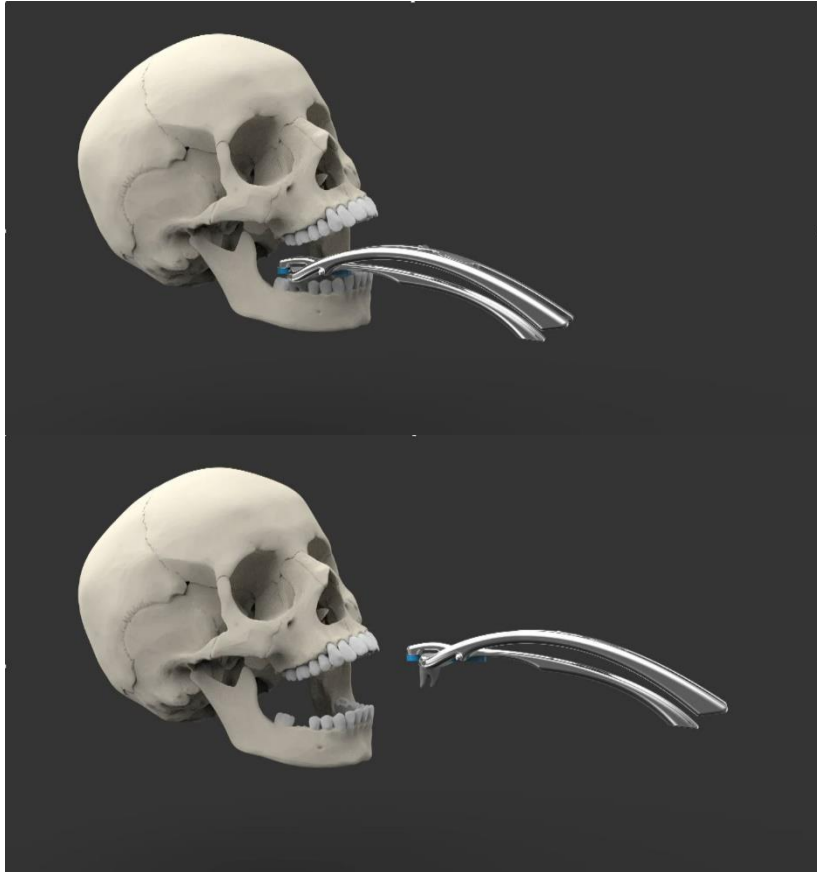
Tooth extraction procedure

Tooth extraction process with developed device is explained in different steps .

1. First step to extract tooth with device will be gripping the tooth which is to be extracted. For that appropriate gripper has to be selected and plier jaws has to be located accurately to hold the teeth actual gripping happens with screw assistance where dentist have to tighten the screw to grip the tooth.
2. After gripping tooth perfectly supporting bridge is to be placed on adjacent tooth as slot on plier matches with the supporting rods in bridge. Slot on plier and protrusion in bridge will form leverage pivot.



Final Concept



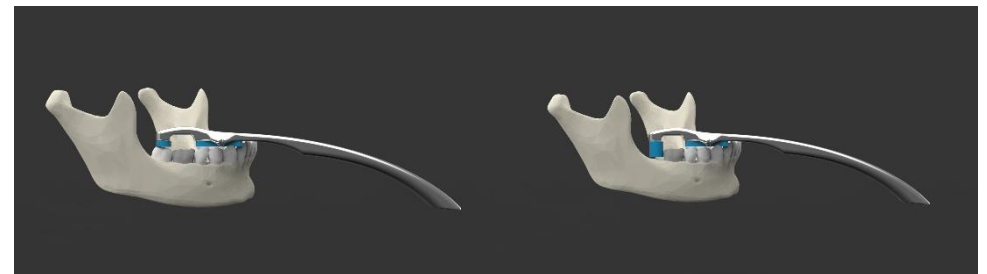
3. Once pivot is formed dentist will get the wedging support from bridge and dentist could wedge out tooth just like plier .
4. This device provides 8 mm power lift which is enough to break all the PDL's and remove tooth from bone socket. Then you can simply lift the setup and take it out.

Final Concept

Detailing of final design

Device have USP of replicable jaw which makes device compatible to extract any tooth by just replacing the jaws

To extract any tooth, supporting bridge should also be capable for various scenario like extraction of 3rd molar where there is no adjacent teeth on one side. Or tooth who's adjacent tooth is already extracted. To accommodate those scenario supporting bridge have replicable supporting pad where dentist could select pad according to the scenario and one device could go in every possible scenario with replaceable support pad.

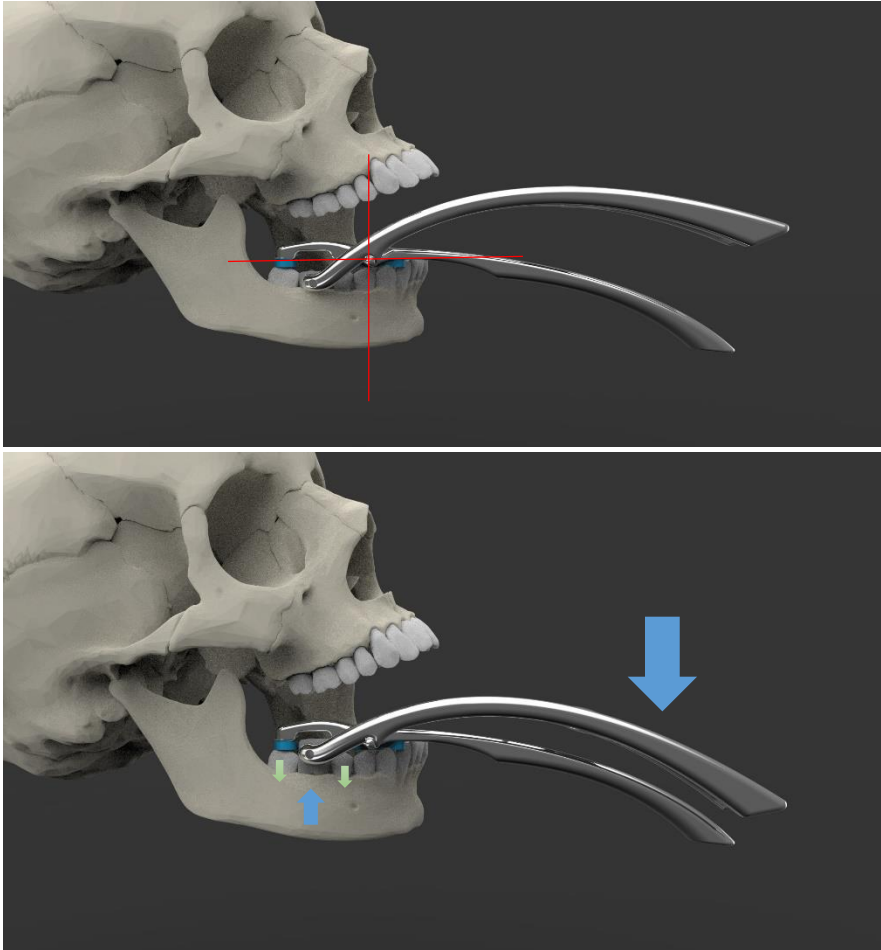


Final Concept

Detailing of final design

Device creates pivot point on supporting bridge which gives leverage advantage to plier for lifting the tooth effortlessly. Plier and supporting bridge forms another plier kind of system which dentists have to press.

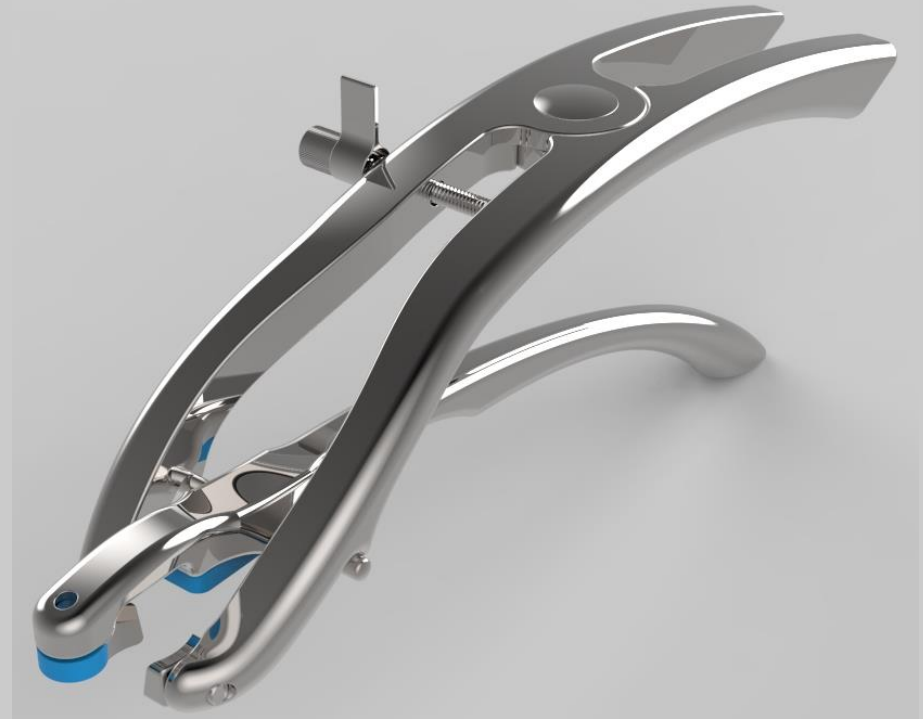
Dentist will be able to generate enough forces to lift tooth from bone socket as dentist have leverage advantage. All the reaction forces generated in tooth extraction is given as compressive load on healthy adjacent tooth. Tooth are designed for compressive load so tooth can easily take those forces.



Final Concept

Design USP

- Effortless extraction
- One device is compatible to extract all premolars and molars with attachments
- Assistive gripping means



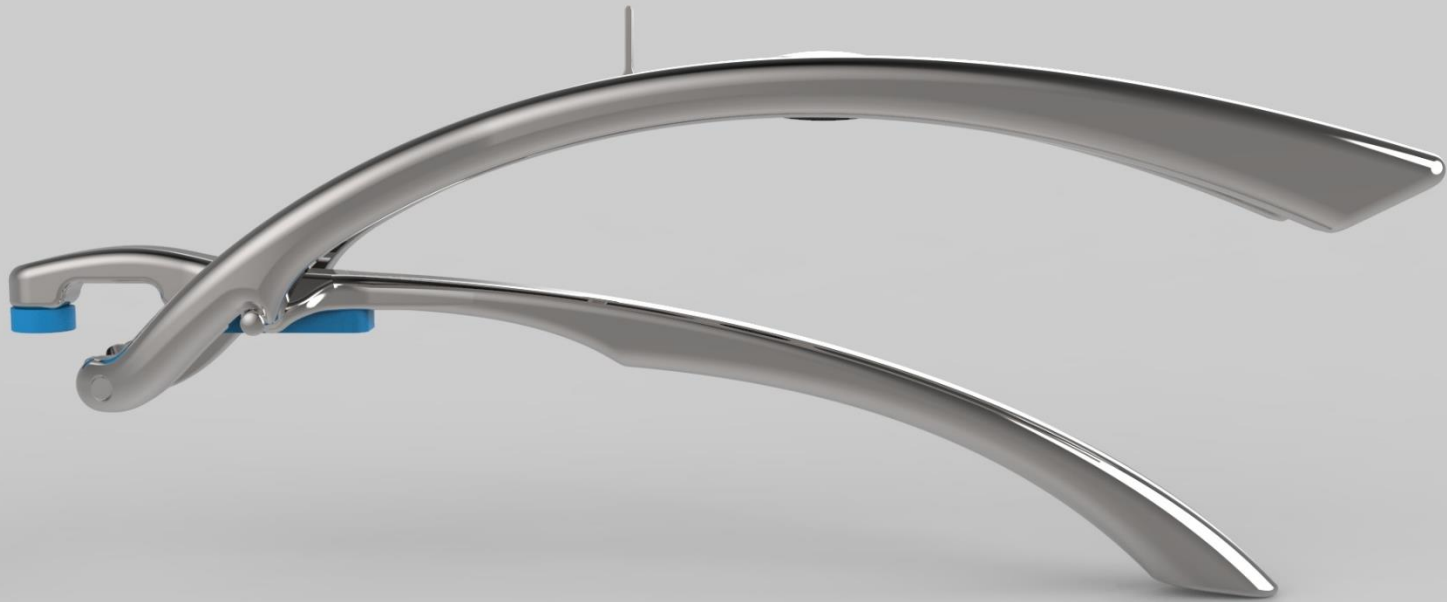
Final Concept

Future scope

- Developing device in Medical grade stainless steel for testing
- First stage test on goat mandibular
- test on patient with collaboration of doctors.
- Branding and packaging design



Final Concept



References

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6. https://www.animated-teeth.com/tooth_extractions/t5_extracting_teeth.htm (As seen on 25.09.17)
7. *Automatic vertical tooth extraction: a proof of principle clinical study of a novel system-*
<http://www.sciencedirect.com/science/article/pii/S2212440312002258>
8. <http://huaban.com/pins/1653921941/> (As seen on 20.12.17)
9. <http://www.justeasy.cn/news/2580.html/> (As seen on 20.12.17)
10. <http://ironmongeryuk.com/fortessa-fdeava-sc-avant-garde-lever-on-rose/> (As seen on 20.12.17)
11. <https://www.hu-friedy.com/surgical/forceps/extraction/99c-kells-forceps/> (As seen on 20.12.17)