

Article

An in vivo Evaluation of Biocompatibility and Implant Accuracy of the Electron Beam Melting and Commercial Reconstruction Plates

Khaja Moiduddin ^{1,*}, Syed Hammad Mian ¹, Mohammed Alkindi ², Sundar Ramalingam ², Hisham Alkhalefah ¹ and Osama Alghamdi ²

¹ Advanced Manufacturing Institute, King Saud University, Riyadh 11421, Saudi Arabia; syedhammad68@yahoo.co.in (S.H.M.); halkhalefah@ksu.edu.sa (H.A.)

² Department of Oral and Maxillofacial Surgery, College of Dentistry, King Saud University, Riyadh 11545, Saudi Arabia; malkindi@ksu.edu.sa (M.A.); smunusamy@ksu.edu.sa (S.R.); oghamdi@ksu.edu.sa (O.A.)

* Correspondence: kmoiduddin@gmail.com or khussain1@ksu.edu.sa; Tel.: 096-611-469-7372

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Table ST1. Implant cost calculation spreadsheet for Electron beam melting.

Cost Distribution Factors	Variables	Cost and Time Period	Summary
	EBM Machine price	\$700,000	-
	Machine depreciation period	10 years	-
	Annual depreciation	\$70,000/year	-
	Basic EBM machine maintenance and service cost	\$36000/year	-
	Annual ownership cost	106,000	Annual ownership cost = (yearly depreciation + yearly maintenance)
	Effective working days (per year)	300 days	-
	Ownership cost (per day)	\$353	Ownership cost per day= (Annual ownership/effective working days)
	EBM Ownership cost (per hour)	\$15	\$353/24
	EBM consumables cost (per hour)	\$14	Reference [ST2]
	$C_{Indirect}$	\$29	Total indirect cost = (EBM ownership cost (\$15) + EBM consumable cost (\$14))
Total build time T_{Build}	Time to obtain desired vacuum level	0.5 h	-

	Time to heat start plate	0.5 h	-
	EBM cool down time	3 h	-
	Build time for 5 implants with mesh	8 h	Total built time for 5 plates= [EBM built time (4 h) + preheating (1 h) time + cooling time (3 h)]
	Build time for 5 plates without mesh	7 h	Total built time for 5 plates = [EBM built time (3 h) + preheating (1 h) time + cooling time (3 h)]
$(C_{Indirect} \times T_{Build})$ 5 implants with mesh	For 5 implants with mesh	(\$29/h × 8 h) \$232	-
$(C_{Indirect} \times T_{Build})$ 5 Implants without mesh	For 5 implants without mesh	(\$29/h × 7 h) \$203	-
$W_{mesh\ plates}$ (Weight of plates)	Weight of 5 Plates with mesh	28.15 g	Weight of a single plate with mesh = 5.63 g
	Weight of 5 Plates without mesh	18.95 g	Weight of a single plate without mesh = 3.79 g
C_{Raw} (EBM raw material price)	C_{Raw} (Ti6Al4V ELI cost price)	\$0.22/g	= \$220/kg
$(W_{mesh\ Plate} \times C_{Raw})$	For 5 plates with mesh	\$6.19	(28.15 g × \$ 0.22/g)
$(W_{without\ mesh\ plate} \times C_{Raw})$	For 5 plates without mesh	\$4.16	(18.95 g × \$ 0.22/g)
EBM energy consumption E_{Build}	EBM Power supply	7 KW [33]	
	E_{Build} (Energy consumption for 5 plates with mesh)	56 KWh	Energy consumption for 5 plates = (EBM power consumption × total EBM built time for 5 plates) = 7 KW × 8 h
	E_{Build} (Energy consumption for 5 plates without mesh)	49 KWh	= 7 KW × 7 h
EBM Electricity Cost C_{Energy}	C_{Energy} (EBM energy consumption cost)	\$0.085/KWh	Electricity tariff = Sar 0.32/KWh (https://www.se.com.sa/en-us/customers/Pages/TariffRates.aspx)
$(E_{Build} \times C_{Energy})$	For 5 plates with mesh	\$4.76	(56 KWh × \$ 0.085/KWh)
$(E_{Build} \times C_{Energy})$	For 5 plates without mesh	\$4.16	(49 KWh × \$ 0.085/KWh)
Manual Hours M_{Hours}	Pre-fabrication time	2 h	Prefabrication includes the time for preparing and processing DICOM files.

	EBM fabrication time	1.0 h	EBM fabrication time consist of time taken in setting up EBM machine and post operation.
	M_{Hours} (Total Manual hours)	3.0 h	Total manual hours = (Prefabrication time + fabrication time)
Labor cost C_{Labour}	C_{Labour} (Labor cost for manual labor)	\$5.33/h	-
$(M_{Hours} \times C_{Labour})$	For 5 plates with and without mesh	\$16.00	$(3.0 \text{ h} \times \$ 5.33/\text{h})$
Cost Model for plates with mesh	For 5 plates with mesh	\$259	$\$232 + \$6.19 + \$4.76 + \16.00
	For single plate with mesh	\$52	$\$259/5$
Cost Model for plates without mesh	For 5 plates without mesh	\$228	$\$203 + \$4.169 + \$4.16 + \16.00
	For single plate without mesh	\$46	$\$228/5$
Commercial available Single Plate		Reference [28]	\$250–\$330

Table ST2. Price calculation of major EBM spare parts (Consumables).

Parts	Price (\$)	Maintenance Cycle (h)	Cost/h (\$)
Start Plate (150 mm × 150 mm) (1pc)	78	400	0.20
Filament F120 (1pc)	1060	100	10.6
Rake blades Long 370 (1pc)	11	100	0.11
Thermocouple 1.5 m	35	100	0.35
Ground ring protection foil (1pc)	45	200	0.22
Heatshield body tall (1pc)	303	300	1.01
Miscellaneous Items		-	1.5
Total Consumable costs			14.0



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